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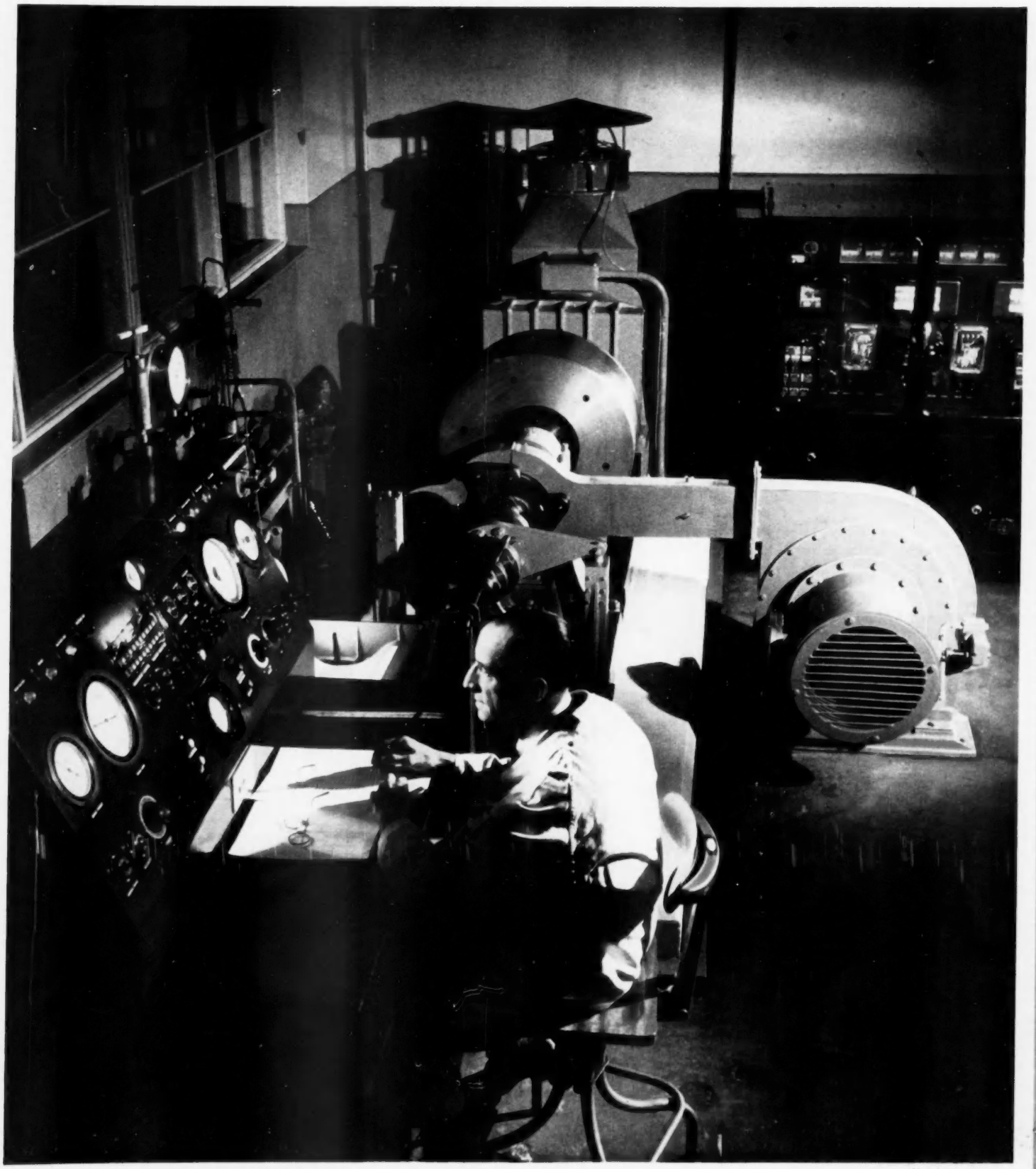

BRAKE MATERIALS UNDER TEST

Nurnberg

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ENGINEERING

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BRAINS IN SERIES

A CORRESPONDENT has reminded us, in a letter published in this issue, that this journal has a responsibility which, he believes, we sometimes neglect. He says that we must " have the ultimate in view as clearly as possible, and not merely encourage willy-nilly any growth, in whatever direction, of engineering technology." We are glad to receive this reminder. As every reader of this journal will know, the essential materialism of engineering produces overtones of an ethical or even a spiritual nature which are certainly not ignored in our editorial columns.

The hydrogen bomb is the latest product of engineering technology to raise doubts which gnaw at the conscience. The will to survive is an animal instinct so deeply rooted in man that it can be suppressed only with great difficulty even when it is presented with a weapon for survival which in destructive power far exceeds anything that man has experienced before. But the coming of the hydrogen bomb has not thereby raised a new issue. The same fundamental issue has been with us since the industrial revolution—and probably for much longer. What is it? What is the fundamental issue that challenges our sense of responsibility and that of everyone in the engineering industries? It is by no means obvious. It is not something reasonably clear-cut, like a man's responsibility for bringing up his children or for giving a fair day's work for a fair day's wage. In fact it is so elusive and, to the individual, so slight that it is easily ignored. Yet we know it is there.

The starting point for a fuller understanding is, perhaps, allied to a familar concept in electrical engineering—the contrast between series and parallel working. In pre-industrial revolution times individual intellects usually worked in parallel; each man generally looked after himself and his family. To-day, in every industrial country, intellects are working in series. This is true in a double sense: they are working in series at any given moment (for example, on all the stages of production from raw material and research to the end-product and its sale); and they are working in series in the historical sense—the scientific work of one generation becomes the practical engineering of the next. Adam Smith saw the division of labour as the way to greater production. We in the Twentieth Century can see the working of brains in series as the way to untold development and invention. But what development and invention, we can only guess. Such is the power of brains in series.

So long as men worked in parallel—that is until comparatively modern times—they were individually accountable for their actions. But now the innocent work of one man may be harnessed by others for destructive purposes. It was never easy to apply the advice to render unto Caesar the things which are Caesar's; now the choice is bedevilled by unforeseeable consequences. And if men continue to make and test—as they do—super-destructive " devices " (surely we don't deceive ourselves with that simple little word?), there is not much comfort for those who regard the television set as the " idiots' lantern." In judgments of this kind we are driven back on what our correspondent has called " the ultimate " in human affairs. But what possible definition of the ultimate would satisfy all followers of all religions and all humanitarian codes?

It would be foolish, however, to despair. The very fact that scientific and engineering brains are now arranged in series presents its own opportunity. Just as an assembly of electrical components in series will only function as long as all the components remain in working order, so a series of intellects will only produce results as long as they all play their parts. On the purely scientific and technical plane there is no sign of a cessation of human inventiveness. But on the moral issues there are no organisations corresponding to the professional societies of scientists and engineers, which have contributed so much to the developments that have caused the dilemma. It is more than likely that no existing society would agree to the suggestion that their members should discuss these moral issues. If that is so, there is a gap in our cultural institutions. Somehow, somewhere, there should be a forum where scientists, engineers, businessmen managers, statesmen, teachers—everyone who is conscious of the inherent tragedy of human affairs—can generate an understanding of the factors involved and thereby introduce a human current into the series circuit of scientific and technical brains. Sir Herbert Read recently said the remedy was " the reawakening of the tragic consciousness and the realisation that there lies at the heart of the human tragedy a redeeming principle which we call—according to the particular mode of thought we use—beauty, truth, or love." Is it really true that scientists and engineers boggle at such wisdom? Or is it that so far they have not organised themselves so as to discuss it?

The Duke of Edinburgh's Study Conference, held last summer, delved into the human problems of industrial communities. Publication this week of the proceedings of that conference (reviewed on page 768) will serve to remind the world that there is still a need to ventilate these problems. But there is a more urgent need to give as much prominence and thought to the issues which

our correspondent has tentatively raised. Every sane person is conscious of the need but there is an understandable reluctance to make the initial moves.

* * *

Plain Words

The electric power signal-box at Cannon Street station was destroyed by fire on April 5. As a result, this important London terminus is not expected to be in full service again until December. Last week there was another, though less serious fire, at a signal box. These events have emphasised how greatly traffic operation at such important centres has become dependent on highly developed and vulnerable equipment.

Happily, signal-boxes seldom take fire. But if everything is destroyed it means the loss of many relays of special type, in addition to more ordinary apparatus, not to mention the extensive local wiring and cable end attachments, together with the lever frame or "panel," as the case may be. As some installations date back 30 years and more it may be difficult, or even impossible, to effect anything like exact replacement. If, for example, one of the original all-pneumatic signal-boxes, of which one or two remain, were to be destroyed there would be no resource but to put in something entirely different. With installations of much later date, difficulties can arise from the fact that many of their components, although generally of a design still being produced, are adapted, say, to work on an uncommon supply frequency.

It is the complexity of the controls, divided among large numbers of track circuit sections in order to obtain the maximum freedom in handling a close headway service, which renders so much apparatus unavoidable in power signal-boxes to-day. And the more extensive the apparatus the more serious must be the situation if fire puts it out of action. The latest London Transport installations have their vital elements spread among several small locations, each operable in emergency as an individual signal-box but normally controlled from a central point. Should the main control room be destroyed, or the circuits leading from it, these subsidiary locations remain unaffected and can be worked.

If power signalling principles and design of apparatus become reasonably standardised using unit construction relays and other components, as is being attempted in Europe, it should prove possible to construct installations which are more readily replaceable than those in service hitherto. If the dispersal method were followed and large concentrations of equipment avoided, risk of such serious dislocation as occurred at Cannon Street would be further reduced.

The British Transport Commission face an unusually complex problem—few of their critics can have an adequate conception of its complexity. For that reason alone, a full policy statement from the Commission would be welcome.

TUNNEL TO PROFIT AND PLEASURE

A proposal to drive a 40-odd mile tunnel from Folkestone to Boulogne, through the chalkbed of the Channel, is currently being canvassed and has already received substantial backing. Lord Mancroft, Parliamentary Secretary to the Ministry of Defence, recently described the tunnel as a "realistic aim" and something the Government would have to reconsider. Over a year ago, Mr. Macmillan, then Minister of Defence, said that strategical objectives to the tunnel weighed "scarcely at all." But such objections have proved the stumbling block of all the schemes put forward ever since the idea was first conceived by one of Napoleon's engineers 150 years ago. Mr. Watkinson, the Minister of Transport, has put the cost of a rail tunnel alone at "something like £100 million."

THE FEAR OF INVASION

A submarine tunnel, it was said, would constitute a threat to the security and traditions of the British Isles. In the 1880's it was described by Sir Garnet Wolseley, the Adjutant-General, as "a measure intended to annihilate all the advantages we have hitherto enjoyed from the existence of the 'silver streak'" A great deal of nonsense was talked about Shakespeare's island even as late as 1929 when Stanley Baldwin charged a committee of the Economic Advisory Council with an examination of the economic implications of the tunnel. The committee reported that "the construction of a Channel tunnel would be of economic advantage to this country." But they found little enthusiasm for the idea in industrial and commercial circles and some hostility among agricultural and shipping interests. The fear of commercial invasion was greater at that time than the fear of Europe's soldiers but the Committee for Imperial Defence were there to reiterate the traditional objections. A motion in favour of the tunnel was defeated in the House of Commons but only by seven votes. Then, as now, politicians were more favourably disposed towards closer relationships with Western Europe than our industrialists and traders.

A CHANGING SITUATION

The rapidly growing support for a Channel tunnel is based on radically changed circumstances. Strategically, the development of nuclear weapons and guided missiles has taken away the value of the "silver streak." There never existed, technically, very serious difficulties in blocking the tunnel without destroying it—by flooding a section—and any opposition on strategic grounds is now very unlikely. The major change of post-war years lies in the inevitability of closer political relations with Western Europe. The arguments in favour of area economic strength, in order to balance the political influence of nations, are familiar enough. Rightly or wrongly, successive British governments have decided that Western Europe plus Britain constitute a potentially powerful economic unit which alone can have the strength necessary to promote the trading and industrial interests of the countries concerned. The concept of a free trade between Western European nations involves certain basic assumptions of equal opportunity, or at least opportunities not too unequal.

For British exporters, the cost of shipping goods to the Continent is at least three times that of shipping them an equivalent distance over land. For example, the cost of moving 10 tons of goods from London to Newcastle by road is £40; to take the same load from London to Paris, over the same distance, costs £130. The cost of sending car to Switzerland amounts to over £30, compared to about one-quarter of this for cars sent from the Ruhr to any Swiss city. For this reason the Society of Motor Manufacturers and Traders are strongly in favour of a tunnel being constructed as soon as possible. The same goes for any industry for which the establishment of a free trade area in Europe is looked upon as an opportunity to expand sales. A tunnel would remove the crippling handicap of the high cost of transport which results almost entirely from the necessity of transferring cargo from road or rail vehicles to ships on this side of the Channel and vice versa on the other.

OPPOSITION WILL REMAIN

The enthusiasm of the supporters of the Channel tunnel and the spectacular rise in the fortunes of the Channel Tunnel Company in recent weeks should not lead one to assume all opposition has been removed. The concept of a submarine tunnel linking Britain to the Continent of Europe has its *raison d'être* in the prospect of a lowering of tariff barriers and a large measure of economic integration between the countries concerned. That this is now Government policy must mean that the Prime Minister and his colleagues will support a tunnel scheme which is teachnically feasible.

Much has been said about high costs of constructing the tunnel. But there were, last year, 1,000,000 tons of merchandise shipped in and out of Dover alone. In addition to this, 1,800,000 people crossed the Channel by sea and returned. Granted lower transport costs there would doubtless be a substantial increase in the flow of all types of traffic; previous experience has always been that the establishment of a new major route brings forth traffic which had not been known to exist until then. Provided our industries are able to compete successfully in European markets, the advent of the free trade area should add considerably to the outward flow of goods. If a tunnel can be built therefore, it matters little how much it will cost. Whatever is decided in 1957 will be found inadequate in 1965, from the British point of view alone. The interest of shrewd United States financial circles in the scheme suggest that a preliminary look at the idea has confirmed the tunnel supporters' contention that it would more than pay its way.

In addition to the outward flow of goods and people, there would be the inward traffic. And there lies the root of most of the objections likely to be raised in this country. European exporters to this country, and particularly German and Italian firms, will find they can substantially reduce the transport costs of their goods, and also improve considerably the speed and quality of their spares service. In this respect the Channel tunnel is not the only contributor. From the German point of view it is part of the broader scheme for a first-class motorways linking all Western European countries. The Italians will see in it something complementary to the Mont Blanc tunnel, which is now going ahead. Those industries and organisations in this country which have so far voiced opposition to the European free trade area are likely also to oppose the driving of a tunnel from Folkestone to Boulogne.

It will be interesting to have the views of the National Union of Manufacturers, who have so far been the most outspoken organisation against Britain's participation in a free trade area. The Channel tunnel would be a bold and imaginative step in the direction of European free trade. It would go further: a 40-odd mile drive (even if the car has to be driven into a fast electric train) is likely to appear a very short distance to people used to several hours in a boat or much shunting about to and from airports. Psychologically it would bring the Continent much closer and the scope for freer movement of nationals across frontiers will be much increased. It would be a mistake to think of a Channel tunnel merely as a means to achieve low transport costs between Britain and France.

Nevertheless, information must be assembled on traffic between the United Kingdom and the Continent, and future trends assessed. This assessment will be exceedingly difficult, since it

must take into account both the effect of the free trade area proposals and of the existence of the tunnel itself as well as the economic trends in the countries concerned, virtually the whole of Europe.

The report will provide information on costs, including construction, maintenance, running and management, and will relate these to the estimates of traffic and revenue. The danger in such undertakings is that the promoters will tend to play down rising trends and approve only the most conservative estimates. A preliminary glance at the volume of traffic which might switch from sea (and air) to the tunnel suggests that whatever is built will be too small to accommodate it. In fact it would be no surprise if in a score years or so there were several tunnels in existence each fully paid for out of traffic revenue. For this reason the plan prepared by the French engineer, M. Basdevant, for a tunnel to take both road and rail tracks, deserves careful consideration, not for its specific features but for the scale on which the undertaking is conceived. The estimated cost of M. Basdevant's tunnel would be between £250 million and £300 million, compared to somewhat less than half for a twin-rail tunnel of the type currently favoured by the majority of engineers who have considered the project.

POSSIBLY A PRIVATE VENTURE

The 76th meeting of the Channel Tunnel Company provided confirmation that there was no lack of interest in the revival of the scheme among financial circles in Western Europe and in the United States. The company's chairman, Mr. Leo D'Erlanger, confirmed that the wealthy Suez Canal Company had taken a lively interest in the project and that an American syndicate is also in the field with an offer of financial and technical assistance. Commenting on the wish of the Suez Canal Company to take "a leading part in a thorough investigation of this subject," Mr. D'Erlanger said "The advent of the Suez Canal Company is highly significant and will be of the greatest help towards the objective, especially if it is going to be achieved by private enterprise."

It has been said that the intention of the Channel Tunnel Company is to reserve 20 to 30 per cent. of the holding in a new company or syndicate for themselves and other British interests; that this should be matched by French interests; and that the Suez Canal Company should hold a substantial stake, leaving room for American participation. The Suez Canal Company would represent international interests in a thoroughfare which should, in due course, carry far more international freight traffic than the Suez Canal ever has or will. Mr. George Picot, director-general of the Suez Canal Company, could well prove to have been as far-sighted in taking his company into the Channel tunnel scheme as Ferdinand de Lesseps was in constructing a canal from Port Said to the Red Sea.

The British and French governments have each substantial holdings, through the nationalised railways, in the Channel Tunnel Company and its French counterpart. It is of course, inevitable that governments should take a leading part in a project so vital to the economic interests of their countries. On the other hand, it is also of importance to have the interests of other nations represented, and for this reason the Suez Canal Company's participation is ideal. The approach made recently by an American company newly formed in New York for the purpose—Technical Studies Inc., who are forming parallel companies in London and Paris—was welcomed by Mr. D'Erlanger, who commented that "it would appear obviously sound policy to reserve the right sort of position for American participation, so that if any larger scheme should materialise from the preliminary investigations it should have the advantage of American financial and technical resources."

PRELIMINARY SURVEY

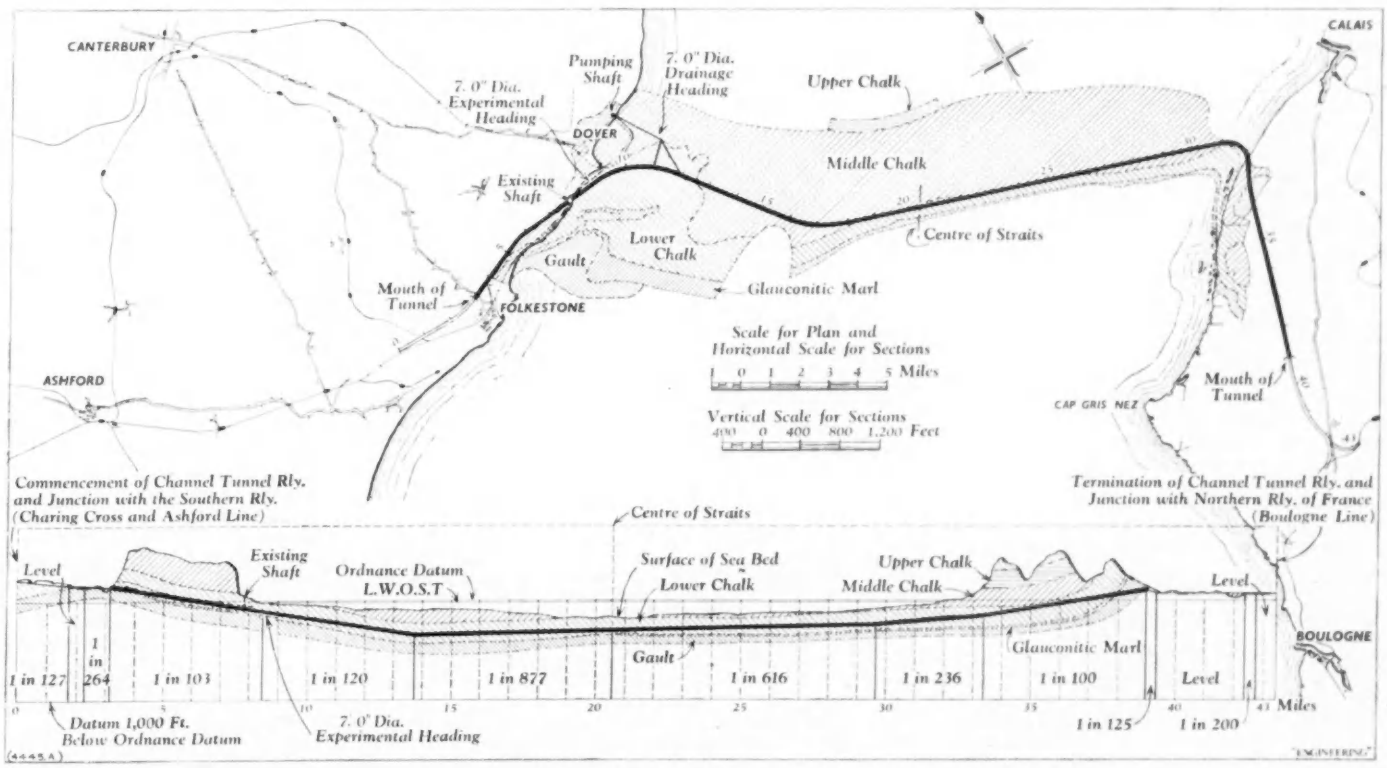
The new company or syndicate to be created by the interested parties will concentrate on making a study of the scheme, that is, to marshal as many relevant economic and technical factors as possible, short of incurring the heavy expenditure entailed by a physical survey, "with a view to assessing, in present conditions, the merits of the whole project." It is expected that the factual information obtained for the Government's Economic Advisory Council in 1930, and the detailed plans based on it, will provide the basic general line of approach.* Long before this survey was carried out, the then South Eastern Railway had begun (in 1881) to drill a pilot tunnel from the foot of Shakespeare's Cliff near Dover, and a similar French working was commenced at Sangatte, near Boulogne. Both these tunnels are still in existence and are in good condition. The engineers in charge of the work on the British side were Sir John Hawkshaw, who helped de Lesseps to build the Suez Canal, and Sir James Brunlees, the builder of the original Mersey tunnel. Both these eminent engineers considered a submarine tunnel drilled through the chalk was a practical proposition.

Informed technical opinion three-quarters of a century later would seem to support them. A great deal of this, however, is based on intuitive knowledge of geological conditions away from the coastal areas. It is not known for certain if the chalk bed is continuous, or of fairly uniform thickness, or without large faults and fissures which would create a major pumping problem. Nevertheless, prior to the tunnelling in 1870 a great deal was done to determine the condition of the strata through which the tunnel would pass and a geological map was made which later work has shown to be substantially correct. This early survey showed, so far as it went and in the words of a report of those days, that there was "no serious rupture of the strata; and at so great a depth as is proposed for the level of the tunnel there is an absence of fissures." In 1882, it was reported in reference to driven headings that "this gallery (from the English side) is now nearly a mile long under the high-water mark and no water has entered it as yet. The mass of rock through which the tunnel is bored is quite dry, but from time to time little tunnels of water are met issuing from cracks in the rock."

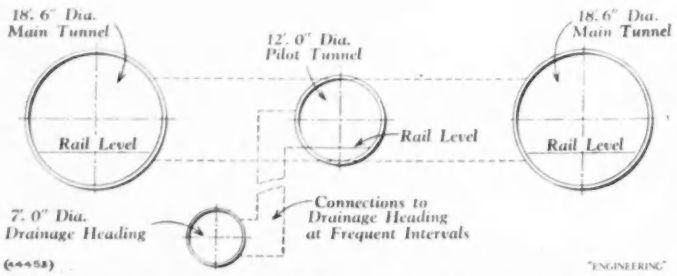
At the time of the 1930 inquiry a panel of consulting engineers was constituted to advise the committee examining the project.† On the basis

* *Channel Tunnel Committee Report*, Economic Advisory Council. Published March, 1930, by H.M.S.O. Cmd. 3513. (3*s*.)

† The panel comprised the following: Livesey, Son and Henderson; Mott, Hay and Anderson; and Rendel, Palmers and Tritton.



In 1930 a panel of consulting engineers suggested this alignment for the Channel Tunnel. The proposed route is almost wholly in the lower chalk, an almost impervious continuous stratum. Success of the project, if carried through, would depend largely on the presence or not of water-bearing fissures in this chalk.



The most likely tunnel arrangement if the Channel Tunnel were promoted. The twin tunnels would be for electric railway stock—road tunnels over the distance would be prohibitive because of ventilation costs. The need for separate pilot tunnel and drainage heading is because of different levels and falls involved in each case.

of the geological evidence available the panel expressed the opinion that the tunnel was practicable and a plan and section were submitted for consideration of the committee; the plan and section are reproduced on the previous page. The factors affecting the choice of the proposed alignment were that the tunnel should be driven on a line below the water-bearing strata of the upper and middle chalk; equally, that it should be on some line above the gault which overlies the lower greensand which has as much, if not more, water than the upper chalk. The only possibility satisfying these requirements was through the lower chalk; the resulting alignment, following the contours of the strata, is shown on the previous page.

The panel, while recognising that the risk of having to drill through rough gravel having direct connection with the sea could not be disregarded, opined that " with the development of engineering resources, fissures, unless of exceptional size, would not present any insuperable difficulty." It was pointed out that compressed-air working could not be resorted to because the head of water involved would be so great as to make conditions impracticable. Since those days, however, the techniques both of cementation and of freezing have been improved and fissures of limited size should not cause any undue trouble.

There can be no doubt, however, that every reasonable method of obtaining evidence about the strata is desirable and there has been much talk recently about the use of an echo-sounding device similar to asdic. It uses sound waves to chart the strata below the sea bed and yields a graph similar to that produced by a barograph with several pens. Although this method—the " sonoprobe " technique—has been used so far only in depths up to 100 ft., it is claimed that it will show quite clearly if the chalk strata are cut by faults or fissures.

But whatever techniques are available, the certain knowledge of the rock conditions that will be met can only be found by driving a pilot tunnel along the line of the final tunnel. If, as all reasonable experience suggests should be the case, the final tunnel consists of two parallel bores, then the pilot tunnel should be driven along the centre line of the route, ultimately providing a passage for tunnel services. The consulting engineers to the 1930 committee advised, however, that the pilot tunnel should not also be a drainage heading; the latter would be driven independently and along a different line which falls in both directions towards collecting points on each coastline whence the water would be pumped out for disposal.

TYPE OF TUNNEL

Leaving aside for the moment the cost of construction, a sound case can be made for putting through both a road and a rail route. It is also certain that, leaving construction and maintenance problems aside, a road tunnel would offer the greatest possibilities. If, however, the size of the tunnels to be driven and, most significant of all, ventilation difficulties are taken into account, and therefore the cost, then the rail tunnel becomes the better proposition.

The turning issue is that of ventilation. If road traffic—including heavy Diesel lorries and ramshackle jalopies—is to use the tunnel, the ventilation has got to be very good indeed. If not, the efficiency of all I.C. engines in the tunnel will drop and the atmosphere will become even more foul. The most satisfactory arrangement are rail tunnels using electric stock. Under these circumstances only sufficient air has to be pumped in to meet the needs of the passengers and maintenance staff. By the use of independent feeds of fresh air at (say) mile intervals along the tunnels and a similar number of extraction points, the atmosphere should be kept reasonable without the use of an enormous plant. The multiple systems of ducting would be carried either in the running tunnels below rail level, or in the former pilot tunnel. Moreover, it would not involve a very ambitious programme to use air-conditioned passenger stock, each coach carrying an air supply for the journey, which will last at the most an hour.

In order that a rail tunnel could offer as much opportunity to road traffic as possible, standard stock could include low-level flat wagons on to which cars and lorries could be run for the journey. Marshalling of road traffic would inevitably involve some difficulties, but average train speeds of some 45 m.p.h. are not out of the question, with a minimum headway of perhaps 3 minutes (equivalent to 10,000 ft. braking distance and perhaps 50 wagons available for service). Incidentally, on these figures the tunnel would be hard put to it at peak holiday periods to meet the want of all those who would seek a continental motoring holiday.

Besides providing a traffic route for both passengers and freight, for both through trains and for " road-traffic " trains, the tunnels will provide admirable ducts for cross-Channel telephone and power cables as well as other services. The lining for the tunnels is also a subject for conjecture. The conventional material for tunnel linings has been cast-iron segments—or, before that, bricks—but it is inconceivable that the iron and steel industries of either the United Kingdom or the Continent could face the demands of the tunnel. Since the war, however, considerable experience has been obtained using pre-cast reinforced-concrete segments. Perhaps the cement manufacturers might be induced to become the most enthusiastic supporters of the project.

A BRIGHT OUTLOOK

The fact that the market price of the 4*s.* shares of the Suez Canal Company rose from 1*s.* in 1951 to 7*s.* in April this year and 29*s.* during May is a measure of the confidence which has built up in the City concerning the prospects of the venture. That this should happen before any new geological survey has been carried out suggests that the political and economic importance of the tunnel have become such that a scheme must go through whatever its cost and difficulties.

Letters to the Editor

TRAINING IN THE USE OF INFORMATION

SIR, Your issue of May 31 carries notes on two aspects of the acquisition and use of technical information in industry. First, despite the existence of the research organisations and the Federation of British Industries, there is the plain fact that many firms are simply not aware of the information that is at hand for them to make use of, and your correspondent Mr. E. G. Baxter, in his letter on page 679, rightly seeks to correct this fault at its source, by proper teaching at the technical colleges in the use of information material. Then, writing, on page 692, of the recent study of trade associations by a Political and Economic Planning group, your reviewer suggests that their present function of gathering commercial information might extend to technical information as well. But, he adds significantly: " This is not to suggest that the nation's already over-drained pool of technologists should be further drawn upon to create staffs of experts for associations which have other defined purposes."

Any proposal to increase a trade association's staff to cope with the technical information requirements of its members should be influenced, *inter alia*, by one important point. There already exists an admittedly imperfect but an increasing and improving service for both commercial and technical information in the public libraries. In London and all the heavily industrialised areas, the reference sections of these libraries form local centres for providing information, and they are fully alive to industry's necessity for speed if the information is to be of practical use rather than of mere academic interest. In most cases, they are supported by arrangements for the provision of information from specialised sources. Before any trade association goes to the expense of additional staff for this purpose, it should first be certain that it will not be depleting " the nation's already over-drained pool of technologists," only to duplicate efforts already available as a public service.

Yours faithfully,
D. R. JAMIESON,
Librarian.

Intelligence Department,
The British Aluminium Company, Limited,
Norfolk House,
St. James's-square,
London, S.W.1.
June 4, 1957.

★ ★ ★

CONSERVING WATER

SIR, Having read with great interest the recent timely contributions to ENGINEERING on the country's water supply condition, we are struck by two features in the arguments. First, there is the positive approach to a remedy by way of huge civil engineering projects. Secondly, there is the apparent resignation to the idea that we must put up with the consumers' demands, whatever they may be.

We feel that some comparison might be drawn between this need for water and the movement for smoke abatement. There, on the one hand, is the centralised research towards a smokeless fuel, which, by tonnage standards, is not progressing too well; whereas the diversified effort to curb the individual user, domestic and industrial, is beginning to be effective. The difference between the two cases is a difference in public awareness. Fog, smog and publicity have turned smoke into a recognisable bogey, which water shortage is not. The answer to that is obvious.

We may mention briefly a few cases in which consumers can make substantial economies without hardship: the shower bath is about four times more economical than the slipper bath; hand basins with properly designed fittings taking ½ gal. per min., save in the same rough proportion (4:1); and w.c. cisterns, now under

investigation, could use less than the present 2 gallons of purified water.

In many industrial processes we find that water does not count unless it is hot, and so associated with a tangible fuel cost. Even so, there is frequently the greatest reluctance to recirculate. The management would rather throw away hot or cold water than install a pump.

We feel that if the water situation could be portrayed in dramatic fashion, with full backing, the response of consumers generally, over a period, could be the most effective and painless solution to our present accumulating difficulties.

Yours faithfully,
W. H. JOHNSON,
Sales Engineer.

Walker, Crosweller and Company, Limited,
Whaddon Works,
Cheltenham,
Gloucestershire.
June 5, 1957.

★ ★ ★

IDIOTS' PROGRESS

SIR, The word "progress," originally meaning a "moving forward in space" and then "growth," has come to signify something like "growth in a good sense"; hence, it is peculiarly difficult to give it a universally acceptable definition, since "good" is undefined and appreciated intuitively. This does, however, lead to a comparatively reasonable definition of "progress" as "movement towards God": begging the question only insofar as ideas of God differ.

Certainly "progress" remains undefined in the public mind, and therefore simple increases in this or that activity (technology, and Communist political organisation, for example) are described by their respective advocates in the general term "progress," with a degree of immunity from criticism; eventually this results in the uncritical acceptance of these increases as real progress.

I feel that it is a prime responsibility of the editor of such a journal as ENGINEERING to have the ultimate in view as clearly as possible, and not merely to encourage willy-nilly any growth, in whatever direction, of engineering technology. Your editorial of March 15 (which attempts to justify advertisement as encouraging technological growth) states: "The salesman does not simply meet the needs of the public, he creates needs that never before existed . . . . . They are . . . the pressure behind progress." This is not the only example in your pages of a misguided, or at least, loose, usage of the term, but is it not a particularly blatant one?

God is omnipotence, omniscience; machinery and research are justified. But what sort of God is it that requires the creation of material needs in the public that never before existed? Is not the God-like action the reduction of material needs?

If the argument needs clarification, read on further in the same editorial: "The scientist may be amused to discover that the paths of electrons emitted from a heated wire can be controlled, but . . . it is only a short step to television sets in every home. It is fundamentally the salesman who makes the step possible." All those who are horrified by what has been delightfully dubbed the "idiots' lantern" will comprehend.

Yours faithfully,
T. J. MURPHY.

Research Department,
Central Electricity Authority,
London, S.E.1.
June 6, 1957.

Editorial comment on this letter will be found in the Leading Article on page 737.

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The index for volume 182 of ENGINEERING is now available, free of charge, from the Publishers. Copies are being sent to those already on the index mailing list.

Weekly Survey

Cover Picture: *As speeds increase, braking becomes more important. The effectiveness of new materials is tested by the repeated braking to a standstill of a flywheel, automatic equipment maintaining a constant braking torque during the cycle and the temperature also under control. Dekatron counters measure the braking time and all operating conditions can be set up from the control panel.*

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Higher Output This Year

The annual forecast by economists on behalf of the Study Section of the Royal Statistical Society is of a rise in industrial output during the second half of 1957. This opinion, which is an average one, goes with a general view of a smaller increase in exports this year than in 1956 and a much larger increase in personal consumption.

The forecast is on the whole in line with the view taken by the Chancellor of the Exchequer in April when he introduced his Budget. The increase in output of 2·6 per cent. infers a substantial acceleration in production in the second half of the year. This is expected to bring with it an improvement in the employment situation and a significant increase in personal expenditure. The increase in exports is expected to be smaller than the actual increase in 1956 and so the home market is expected to take the major part of the increase in industrial output. In order to meet rising production, an increase in stocks and work in progress is forecast (compared with an actual fall in this item last year) and this in turn is expected to place a slightly greater strain on the balance of payments than last year. On this analysis the slightly reduced rate of increase in exports may be hard put to it to meet the rising import bill. This is the kind of situation which the Chancellor of the Exchequer had in mind when he said in April that the industrial machine must not be allowed to generate too much activity too quickly. There is, indeed, little prospect of an easing of the credit situation until the increased production which is already raising the import bill finds its way into exports instead of into the home market.

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Copper Prices

Over the past twelve months the price of copper has fallen from a peak of £437 per ton to £300 at the beginning of this year and to a current level of about £235 per ton. The main reason for this is that world consumption, after increasing rapidly for several years up to 1955, has since remained virtually steady, while production has continued to expand by about 10 per cent. per annum as long term development programmes have been completed. It has been clear for some time that the downward trend of prices could only be halted if supply and demand were brought more closely into line, but there were few signs of this occurring either through increased consumption or the closing of high cost producers, though Granby Consolidated Mining in Canada and the Howe Sound Company in the United States have announced that they are ceasing production.

The first attempts to restrict production by the larger producers were made a short time ago in the United States in an attempt to hold the price at 32 cents per lb., equivalent to about £250 per ton. The Anaconda, Phelps Dodge and Miami Companies have announced cuts in production amounting to about 4,550 tons per week. Outside the United States the Rhodesian Selection Trust group have announced that production from the Roan Antelope and Mufulira Mines would be reduced by 10 per cent.—equivalent to about 18,000 tons per annum. Even after allowing for these cuts, however, it is estimated that world production exceeds world consumption by about 150,000 tons per annum. The Anglo-American group have stated that they do not intend to reduce output, and a cut in production by the Union Minière du Haut Katanga, the largest producers outside the United States, is considered unlikely.

The announcement at the end of May that the Anglo-American Corporation and the Rhodesian Selection Trust had agreed to adopt a joint pricing policy for copper is further evidence that producers are determined to prevent a further fall in price. Details of this agreement will not be published until it has been considered by the principal consumers, but it is probable that the latter would welcome a greater measure of stability in prices, provided that the level at which stability is reached is considered reasonable. The chairman of British Insulated Callender's Cables, for example, recently pointed out that B.I.C.C. have co-operated fully over the last two years with the efforts of Rhodesian Selection Trust to introduce a measure of price stability.

While the measures so far announced may succeed in maintaining a more stable price in the short run, they are clearly insufficient to restore a long term balance between production and consumption and, in the absence of any marked revival in consumption, the lead given by Rhodesian Selection Trust will have to be followed by similar measures on the part of the other leading producers, preferably as a result of agreement between them and the major consumers.

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Optimism in Coal

For the first time since the war, the National Coal Board were able to present a much improved picture of operations. The large investment in new machines and the improvement in working conditions are beginning to pay off. From now on, improvements should be more marked. Output in 1956 was slightly higher than the previous year and 17 per cent. higher than that in 1946, the last year before nationalisation. So far this year, output has been rising most encouragingly, and is expected to be 3 million tons higher in the first half of 1957 than in the corresponding period last year. Presenting the Board's annual report and accounts for 1956, their chairman, Mr. James Bowman, said that the industry entered 1957 "in better shape than at any time since the war."

The target is 21 million tons more in 1965 than in 1956, an average annual increase of 2·4 million tons. Productivity is now rising steadily, less time is being lost through disputes (although the number of disputes is "still disturbing") and less coal is having to be imported. In 1956 the Board made a profit of £12·8 million after depreciation. Yet Mr. Bowman wants an increase in coal prices. He argues that costs have risen, and that the Board must invest heavily in new plant and machinery. They have received official sanction for capital expenditure of £1,000 million over the next 10 years, between half and two-thirds of which is expected to be found internally. If no action is taken to offset rising costs, the coal industry will be unable to play its part in equipping its mines and will once again run into the red. Last year the price of coal was raised by 6*s.* a ton while production costs rose by 7*s.* 2*d.* The recent wage agreement will cost £10 million a year, and the removal of penalties for absenteeism a further £3 million. An accumulated deficit of £23·8 million remains to be paid off. Unless prices can be increased it is unlikely that all this could be found. Certainly, the scale of internal financing of last year—the Board found £81 million of the £95 million spent on capital development—could not be repeated.

There will be protests in plenty at the price

increases. Yet any industry must charge a price for its products which will yield reasonable profits and United Kingdom pithead coal prices are still the lowest in Europe. If the Board's price policy was to become governed by what was deemed to be "nationally desirable" and "politically feasible," the whole responsibility for profit and loss would become the Government's. It is the rate at which new equipment is being installed, power loaders in particular, which will decide the eventual level of prices. Mr. Bowman's charge that the rate of development is being limited by the mining machinery industry's ability to fulfil orders quickly requires answering.

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Reduction in Steel Tariffs?

Last week's discussions on import duties on iron and steel products at the fifth meeting of the Council of Association between the United Kingdom Government and the High Authority of the European Coal and Steel Community are an interesting foretaste of the problems likely to arise from United Kingdom participation in a European Free Trade Area. Owing to the relatively strong position of the British steel industry, however, the ease with which a provisional agreement appears to have been reached may not be repeated in all cases. It is reported that the United Kingdom delegation offered to reduce import duties on steel to 10 per cent. ad valorem from the present levels, which vary from 15 per cent. to 25 per cent. provided certain counter proposals were accepted by E.C.S.C. countries. These counter proposals, of which details have not yet been published, are likely to be considered at the next meeting of the Council of Ministers of the E.C.S.C. on June 19.

On February 10, 1958, the E.C.S.C. will reach the end of its transitional five year period, and by that date the member countries must introduce a common tariff level, which is likely to be considerably lower than present United Kingdom tariffs. Although the United Kingdom was under no obligation to reduce tariffs, the High Authority was anxious to secure such a reduction when European tariffs in general are reduced. In practice, United Kingdom import duties on many iron and steel products have been suspended for the past two years, though they were recently re-imposed on certain products.

Since United Kingdom steel prices are in general lower than those prevailing in Europe, the British industry is unlikely to suffer hardship from a reduction of tariffs so long as European demand continues at a high level. There has, however, recently been more intensified competition in export markets accompanied by a fall in export prices. Although this may well prove a temporary condition it would not be unreasonable for the British industry to seek guarantees against exceptionally low export prices in return for concessions on United Kingdom import duties.

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Nerves of Steel

Among the annual reports of steel companies ublished recently are those of several makers of hard steels, forgings and castings. Arthur Balfour, Darwins, English Steel, Guest Keen and Nettlefolds and, from Germany, August Thyssen-Hütte. All tell stimulating stories of expansion and modernisation schemes but several of them display at least some nervousness concerning the future. The scale on which capital investment is taking place is sometimes obscured by the publicity given to shortages, particularly of alloy steels. G.K.N. contemplate spending over £30 million over the next three to four years, including two major schemes at John Lysaght's Scunthorpe works and Brymbo Steel Works, as is discussed in detail in the next note. Their chairman, Mr. K. S. Peacock, took a fairly sanguine view of the future, though he emphasised the difficulty of assessing demand for some of their products, such as forgings for the motor industry. Since the group's prosperity depends "largely on general economic conditions" he concluded, their strength lay in their "widespread activities at home and abroad." The group's trading profit of £21·3 million—after charging £5¾ million to depreciation—was some 25 per cent. higher than last year and suggests a very healthy growth and progress.

English Steel, a substantial though much smaller group with a turnover last year of some £45 million, took a cheerful view of the future. This was partly on the assumption that the revival in the motor industry would permit "resumption of capacity productions in those departments which have been short of work." Arthur Balfour and Darwins, both prominent makers of alloy steels, reported higher profits, but expressed concern with the uncertainties of the future. The chairman of Balfour, the Hon. R. A. Balfour, complained that the future was "less reassuring than at the same time last year." Mr. P. Thompson-Schwab of Darwins commented on "the many hazardous factors which are operating at the present time" and make the forecasting of next year's results very difficult. On the other hand, with good equipment and able personnel, "the future can be faced without misgiving."

August Thyssen's report is a splendid production, which would stand comparison with most prize-winning reports in this country or in the United States. It tells a story of rapid expansion to catch up the lost years of the control commission's embargo. They are busy acquiring sections of their vast business which were lost under the deconcentration scheme and will shortly be back to pre-war strength and eminence. A 10 million dols. loan from the Export/Import Bank of Washington and a joint undertaking with Armco International Corporation for the production of "new kinds of flat steel products" suggest substantial United States assistance. The frankness and comprehensiveness of the report, which is translated into good American, provides an unusually clear insight into the steel industry of West Germany.

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Guest, Keen and Nettlefolds' Expansion

When the Prime Minister announced that he had asked the Chancellor of the Exchequer and the Minister of Labour to consult with representatives of industry on whether an independent body might help to throw light on the different aspects of price stability and the need for greater productivity, he stressed the necessity for both sides in industry to understand the problems and needs of the other. He emphasised that an important factor in developing a sense of partnership between management and labour is knowledge about the real facts of an industrial firm, including the balance sheet and the use of profits to maintain investment. There has in recent years been a considerable improvement in the amount of information which the majority of companies include in their annual reports, but there is still a good deal of ignorance regarding the importance of retained profits in providing capital for modernisation and extension of capacity.

A good example of this latter point is provided by Guest, Keen and Nettlefolds, Limited, who are shortly to raise £16 million by a rights issue to ordinary shareholders. A statement issued last week with the company's accounts outlines a programme of capital expenditure totalling £30·3 million, which should increase group assets over the next three or four years by some 50 per cent. Of the total sum, £13¼ million is required for capital expenditure by John Lysaght over the next three or four years and £1¾ million by Brymbo Steel Works, Limited, over the next twelve months. The company's "ordinary modernisation and development programme" involved an expenditure of £11½ million in 1956, and this expenditure is not expected to fall during the next three or four years.

The company's depreciation allowance has risen over the last three years from £2 million per annum to £5¾ million, and is expected to average £6½ million over the next three years. In addition, retained profits amount to over £7 million per annum. A total of nearly £12 million was thus available in 1956 for modernisation and development and this compares with total preference and ordinary dividends of £2·1 million. Thus of a total trading surplus before depreciation of £27 million, depreciation and retained profits accounted for 47 per cent., taxation for 41 per cent. and dividends for 2 per cent.

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The Changing World of Vickers

When Lord Knollys, Vickers' new chairman, gave shareholders statistics of the company's output at last week's annual general meeting, he revealed the full extent of post-war changes. Aircraft are now the principal product of the group, accounting for 40 per cent. of turnover (32 per cent. in 1955), followed by general engineering with 25 per cent. (of which punched card machines and computers are about a sixth); steel (a 75 per cent. interest in English Steel Corporation) is third with 20 per cent., and shipbuilding and ship-repairing last with 15 per cent. The total sales of the group in 1956 amounted to £163 million, an increase of £31 million on the previous year. Profits were higher, but profit ratios lower—7·8 per cent. on turnover and 13·5 per cent. on capital employed. Lord Knollys did not attribute the fall in profit margins to rising labour costs, as is the fashion, but "to our efforts to diversify and develop for the future." He pointed out that some time must pass before the results of this policy are reflected in the profits.

The statistics quoted above tell the story of Vickers' post-war metamorphosis better and more concisely than words could do. The prominence of aircraft is due to the success of the company's airliners rather than to military production. The profits are now beginning to come in from the Viscount production. Two civilian projects, both private ventures of considerable magnitude, will if successful place Vickers in the leading position in the aircraft industry. The Vanguard is due to come off the line in 1960 and the new straight jet VC 10 in 1963. B.O.A.C.'s orders for 35 of these large aircraft—secured in competition with the projects of several other companies—could mean that the Corporation were influenced not only by the excellence of the design but also perhaps by Vickers' own confidence, expressed by their chairman, in their ability "to sell sufficient aircraft to recoup our expenditure, and to make a fair profit in due course." Shipbuilding has increased slightly in importance among the group's activities. They are preparing themselves to meet the changed demand "for still larger tankers" and "the increasing interest in nuclear propulsion for ships." Together with Rolls-Royce (with whom the group's commercial ties become closer with each new project) and Foster Wheeler, Vickers are to build the first British nuclear-propelled submarine, Dreadnought. This, and the building of the Navy's new carrier-borne fighter Scimitar, are the only significant armament projects on the Group's books. Steel production, centred in the English Steel Corporation group of companies, requires to be considerably expanded, but the shortage of suitable heavy structural steel will delay the new building at Tinsley until next year.

Vickers' forward policy was described by Lord Knollys as keeping the company's eye on "the trends, the needs, the gaps of the future." Their object is to cover "many fields where we can see new, greater or different

demands: aviation, guided weapons, mechanisation (I will not call it automation) and electronics, earthmoving equipment, nuclear propulsion, most of which are in their earlier forms traditional to Vickers." Such pattern of development, possible for only the largest of companies, may well become the model of operations in the metal and engineering industries. What may to some appear as unnecessary variety could become a *sine qua non* of successful expansion.

* * *

Prospects for Private Airlines

A broad hint was given by Mr. Harold Watkinson, Minister of Transport, that a new deal was in prospect for private airlines. Replying to questions in the House of Commons recently he said that "before long" he hoped to bring before the House some proposals likely to be "of value to private enterprise airlines." The questions arose from apprehension on the part of some M.P.s concerning a change in the Government's attitude, following B.O.A.C.'s purchase of Central African Airways. It had been generally believed that Mr. Watkinson's proposals would include the operation of Colonial Coach Service by independent airlines—designed to create a new class of cheap travel appropriate for older type aircraft and reserved for the Independents.

For some considerable time now the Government have been considering ways in which private airlines could be allowed to carry passengers on scheduled flights, and so considerably increase their activities. Mr. Watkinson's reply to Air-Commodore Harvey's question concerning whether or not B.O.A.C. were within their rights in conducting such a deal was that the matter was not one in which the British Government could intervene. It was a decision by a sovereign government of Africa, and one which they were fully entitled to take.

A protest may have been made by Hunting Clan Air Holdings, who requested to see the Minister on the same day, but it is not easy to see on what grounds. The deal was made on a purely commercial basis, and no expenditure from public funds was involved. Consequently any objection would have to be based on the right of the Government to interfere with the commercial decisions of the Corporation, presumably in order to restrict B.O.A.C.'s ability to compete with private airlines in making the type of deal they had made with C.A.A. If so, this is strange talk on the part of avowed champions of the right to run a business on an unfettered commercial basis.

A NEW INFORMATION SERVICE BASED ON THE TECHNICAL COLLEGES

By G. H. Wright, A.L.A.*

Dr. E. Martindale, liaison officer for the Department of Scientific and Industrial Research in Scotland, emphasised two important points in his recent paper on "Lines of Communication."[1] He maintained that information centres will prove of little value if there is no effective liaison between the centres and the people they are intended to serve. He also emphasised that it is vital for students of science and technology to be taught how to use libraries and other sources of information. Such training, he considered, would be of greater value than examination papers when the student went into industry.

Most firms employ a staff of salesmen or business representatives either to sell their product or at least to see that it is widely known among those to whom it could be of use. Research associations and information centres also have to see that the information they possess is passed to those who would benefit by being aware of its existence. Unfortunately, most of these organisations, because their product is less tangible than a machine, operate on a small budget and can rarely afford to provide an effective liaison or sales team. A firm will spend much time and money seeking a new machine to meet its requirements but rarely goes to the same trouble in searching for information. If it did, the burden of providing liaison teams could be shared. It may not be generally realised how valuable such contact between industry and information centres can be, for it is only by being fully aware of the specific needs of each organisation that the information centre can give maximum assistance.

As Dr. Martindale says, part of the reason for the present state of affairs lies in the inadequate training given to the scientist and technologist, who enter industry unaware of the potentialities of the majority of research and information centres. In a recent letter published in ENGINEERING,[2] Mr. Baxter pointed out that only a few of the more enlightened colleges are likely to carry out such training until "the syllabuses of the engineering institutions and of the colleges themselves are widened to make such knowledge compulsory." Fortunately, as recent Government publications[3] illustrate, the Minister of Education is well aware of this need. It is now time for the examining bodies to follow the Minister's lead. It is by no means unusual to discover a recently qualified student happily putting letters after his name yet knowing little or nothing about the history and activities of the Institution which has granted them. And it is rare to find a student who is fully conversant with abstract journals, publications and research association activities covering his chosen vocation.

The problem of disseminating information and training students to appreciate the resources available to them is being tackled as a single entity in the County of Hertfordshire. Unlike many areas, Hertfordshire is fortunate in that the County Council is responsible for all technical and further education in the county and, apart from five municipal areas, is also responsible for the public library service. Under these circumstances it is much easier to plan an effective information service for industry than it would be in areas where a number of different rate-paying authorities would have to co-operate to initiate such a scheme. In addition, there are a number of excellent research association and industrial libraries in the county, all of whom actively co-operate among themselves and with the County Library.

The new Hertfordshire Technical Library Service will be an integrated county library service based on all the technical colleges and colleges of further education in the county. The three technical colleges at Hatfield, Letchworth and Watford will be the primary information centres, actively engaged in disseminating information to industry within the special subject fields for which each college is educationally concerned. Agriculture and building interests will be met by the Oaklands Institute of Agriculture and the St. Albans College of Further Education, where the county's advanced building courses will be operating. Though delineating information by subject is rarely successful it is hoped that the close co-operation which will exist between each unit will serve to overcome that disadvantage.

The colleges of further education meanwhile will provide an information service at a different level. They will each house trade catalogues and provide a detailed index to trade names and products. It is expected that the service these colleges provide can be easily handled over the telephone. The co-operation of firms in supplying and maintaining their trade catalogues is obviously essential for the success of the scheme but it is hoped that such co-operation will be forthcoming.

Housing this service within a technical college has some important advantages. If industry uses the facilities effectively, the student will soon be aware that the library is serving a valuable purpose to the industry to which he belongs. Such a realisation can help to overcome the student's present lack of appreciation of the practical benefits that a library can give him. The scheme, however, is also taking into account the need to give more effective training in the use of information sources. Though the libraries will be closely integrated with the college courses, some definite training in the use of a library is envisaged.

In the colleges of further education a tutor librarian will be responsible for giving lectures and individual assistance to encourage the student to become generally aware of the recreational and practical value of a library. In the technical colleges where the student attends the advanced training in his technical subject, he will be given lectures on information and on report writing. Courses have been designed to show the student how to seek, collate and present information.

The importance of a liaison service to industry has not been overlooked. It is hoped that regular contact will be possible. Such a service will be strengthened by the very nature of the co-operation that already exists between industry and the colleges. College departmental advisory committees, part-time teachers and the majority of the students are drawn from local industry, and the encouragement they will be given to use the library information facilities will all help to provide a mutual liaison service. The availability of specialists on the college staff will also be beneficial in handling information inquiries and in assisting liaison.

In addition, to assist and advise on the scheme, the County Council has formed a small advisory committee. The members on this committee hold important positions in industrial, trade and research organisations within the county, and are in an excellent position to give the Council guidance in the promulgation of an adequate information service.

Liaison with local industry will be strengthened by a card and bulletin service. A technical bulletin, acting as a forum for information on College activities and providing answers to inquiries, will be available on subscription together with a card service giving details of books, reports and periodical articles added to stock. This latter service will be provided according to the subject interests of each subscribing firm.

No such scheme can hope to be all embracing. Co-operation with existing information services is essential. The best chance of arousing interest in national information research establishments is by increasing the local awareness of their potentialities; this, it is hoped, will be achieved in Hertfordshire.

The wheel is now turning and the Minister has shown the direction he wishes it to follow. Will examining bodies and industry be prepared to oil the bearings? The time will surely come when some enlightened body will state that their examinations must be held in a technical library and the students must be free to consult technical information resources.

* Technical Librarian to the Hertfordshire County Council.

REFERENCES

[1] "Lines of Communication," by Dr. E. Martindale, commentary in *Technology*, June, 1957, page 130: "Russian Scientific Literature Ignored."

[2] "Training in the Use of Information," by E. G. Baxter, ENGINEERING, May 31, 1957, page 679.

[3] *Technical Education* (Cmd. 9703), H.M.S.O., 1956; Circular 322, "Libraries in Technical Colleges," Minister of Education, 1957; Circular 323, "Liberal Education in Technical Colleges," Minister of Education, 1957.

MORE ABOUT SEASLUG

Further details of the Royal Navy's ship-to-air guided missile known as Seaslug have been disclosed by the Admiralty. Seaslug is a medium range weapon designed to engage any enemy bomber which evades the fighter defences of the fleet. It will do so at any height at which modern aircraft are capable of operating. The first ships in which the weapon will be fitted are the four guided-weapon destroyers which have already been ordered by the Admiralty. These ships are to be based on the design of the present Daring class ships but will be larger than the Darings.

Seaslug is propelled by a sustainer motor and four booster rockets. The latter are jettisoned after propelling the missile to supersonic speed.

Seaslug is operated and fired from positions within a ship without any personnel being required to be on duty in exposed places. Although a large number of officers and men are engaged in the maintenance of the missile equipment and in preparations for firing, the number engaged in the actual operation of firing is far smaller than the crew of a conventional gun turret in a major warship.

Targets are detected at long range by radar, and subsequently plotted accurately for range, height and bearing. From this information a particular aircraft may be selected as the target for the missile. The details of the target's range, course and speed are obtained by the missile guidance and control system and used to position the weapon launcher, and enable the operator to determine when to fire the missile. This he does without ever seeing the target. Missiles are fired from a triple ramp launcher which is automatically fed from a magazine below decks.

The weapon has been developed by the Ministry of Supply, and has been tested at the proving grounds of Aberporth in Wales and Woomera in Australia. At Aberporth some trial firings were made from the Clausen rolling platform which is a mock-up of part of a ship floating in a concrete basin and capable of simulating all the conditions of roll and pitch likely to be encountered at sea. Since the commissioning of H.M.S. Girdle Ness, the Royal Navy's guided-weapon trials ship, last July, firings have been carried out at sea of which the vast majority have been successful.

All seaborne equipment, apart from the missile itself, has been developed under the direction of the Admiralty; this includes the launcher, magazine handling gear, radar and associated weapon direction and control equipment.

Sir W. G. Armstrong, Whitworth (Aircraft) Limited, Coventry, are the co-ordinating contractors for Seaslug. Other firms intimately associated with the development of this weapon system are:—The General Electric Company Limited, Sperry Gyroscope Company Limited, John Thompson Conveyor Company, Sir Geo. Godfrey and Partners, Limited, Vickers-Armstrongs Limited, Metropolitan-Vickers Electrical Company Limited, McMichael Radio Limited, E.M.I. Engineering Development Limited, and Imperial Chemical Industries Limited.

COMPUTING CENTRE

The IBM computing centre was opened recently at 101 Wigmore-street, London, W.1. A type 650 digital computer can be hired there at a basic rate of £30 an hour, and consultant, library, and training facilities are available. It is expected that a large machine of the 700 series will be installed there soon. Sixty per cent. of the total holding of IBM United Kingdom Limited is owned by the IBM World Trade Corporation, which is an independently-operated but wholly owned subsidiary of the IBM Corporation, New York.

Throughout the world some 700 type 650 computers have been installed, and a further 1,500 are on order. Production at the Endicott factory, New York, is about 40 per month. In the United Kingdom the machine has been used to study the relative merits of irrigation and hydroelectric power schemes on the River Nile—an operation in which the computer traced in 13 minutes the history of the river, month by month, for a period of 48 years. Coal transportation and distillation column problems have also been studied. A 704 machine recently installed for the United Kingdom Atomic Energy Authority is said to be one of the largest digital computers in Europe. There are now 126 of the type 705 machines installed, and production is at 10 to 12 per month. A 704 machine is to be used to track and compute data for the proposed artificial satellite.

The type 650 computer, now in production at Greenock, Scotland, and around which the new centre is designed, is a medium sized machine with a basic cost of £80,000. Unlike many British machines, it does not work on a binary code. Numbers are represented in the biquinary system. That is, each character is represented by a seven-part code symbol which is subdivided into groups of two and five. The presence of the correct number of parts in each of the sub-groups serves as a check on errors. Storage is by magnetic drum rotating at 12,500 r.p.m. It is a cobalt-nickel plated metal cylinder 16 in. long and 4 in. diameter, and stores 2,000 ten-digit words. The average access time to data on the drum is 2·4 milliseconds.

A feature of the IBM system is the building-block principle employed. Various types of input and output devices are available, enabling punched cards to be handled and printed outputs to be obtained. An immediate access magnetic core storage may be added to the calculating unit to avoid the delays caused by the relatively long access time to the magnetic drum. The core storage will hold 600 digits of data and instructions and is used in the intermediate steps of a calculation; the magnetic drum still constitutes the main store. However, should the drum provide insufficient storage, magnetic tape or magnetic disc units may be used. Magnetic tape (not to be confused with magnetic film) is used in reels of 2,400 ft. length with characters written at a density of 200 to the inch. The tape requires 10·3 milliseconds to get up to reading speed and will then read or write at 75 in. per second. Historical data subjected to repetitive use—such as personnel and payroll records—are usually fed on to the tape from a punched card input and may be rapidly amended week by week. Up to six tape units may be used in one system. A further means of storage that can be used with the 650 computer is magnetic disc storage. Each unit has a stack of 50 discs, rotating at 1,200 r.p.m., with a total storage capacity of 6 million digits. Up to four units may be used in any one system. The feature of this system is that access may be had at random to the stored data. In conjunction with the disc storage an inquiry station may be used that permits the extraction of specific information, such as the inventory position of an item or the stage of an account. The data requested can be located rapidly in any of 12 storage units and typed out as desired.

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THE FUNCTION OF THE INSTITUTION OF METALLURGISTS

The importance of the human and personal side of the metallurgical profession was discussed by Mr. James Mitchell, C.B.E., a director of Stewarts and Lloyds, Limited, Corby, Northamptonshire, the newly-elected President of the Institution of Metallurgists, when delivering his presidential address in London on May 21. He stated that the classification of the medical profession into general practitioners and specialists was also applicable to metallurgists, although, in metallurgy, there were more specialists and fewer general practitioners. The accumulation of knowledge over the years had been applied with outstanding success in the introduction of new techniques in the metallurgical profession. The experienced and mature metallurgist might provide, with considerable advantage to the profession, a larger proportion of the published papers.

To the query frequently heard from the members—"Why does the Institution not publish technical papers?" the answer was that, in the first place, the technical societies and the technical Press already more than adequately fulfilled this function, while the information services run by the technical institutions ensured that the requirements of those desiring to explore specific lines of work were met. The function of the Institution was not to spread metallurgical knowledge directly by publication or otherwise, but, being satisfied that this was done, to ensure that, in the light of this knowledge, the standard of practising metallurgy was being maintained by individual members. This maintenance of standards in the entry to, and the practice of, the profession was in the nature of an intangible and vital service to all qualified metallurgists, and, incidentally, to all employers also. An individual member who asked "what do I personally get out of the Institution?" was being not only a shade selfish but really quite irrelevant. One could also assert with confidence that the influence to the Institution's ideas in the training and qualification of metallurgists, which ideas were being consistently pressed in the right quarters, in due course, would lead to a still higher standard of practice and increased respect for the metallurgist as an important unit in the body politic.

CONTROL OF FIRES IN FACTORY BUILDINGS

A method of controlling an outbreak of fire in a factory building was demonstrated recently in a graphic manner at the Cowley Bridge Works, Uxbridge, Middlesex, of Cape Building Products Limited.

A specially-constructed test building was employed and this is a tubular-steel framed structure 30 ft. in length, 20 ft. in width and having a height to the apex of 20 ft. 6 in. The structure is divided into three equal bays, the "fire" compartment occupying two of the bays and the third bay being protected. Externally the building is covered and roofed, on one side, with standard corrugated sheeting and on the other side with R.P.M. (Robertson's Protected Metal) and with Galbestos corrugated sheeting, both of which are manufactured by Robertson Thain, Limited, Ellesmere Port, Wirral, Cheshire. The R.P.M. sheeting consists of a mild-steel base which is given a bitumen coating, then an asbestos felt covering and finally a hard bitumen outer covering. The Galbestos sheeting is first galvanised, then the asbestos felt is pressed on, and finally the hard bitumen coating is applied. The roof of the building is lined with Cape Building Products' Asbestolux asbestos insulation board suspended in Asbestolux-protected steel T sections, with "Rocksil" building matting laid over the back of the lining. Rocksil is a long-fibred rock wool manufactured from natural dolomite and fireclay, and made up into mats, slabs and mattresses at the Cape Asbestos Company's factory in Stirling. The walls are lined with Asbestolux panels backed with Rocksil.

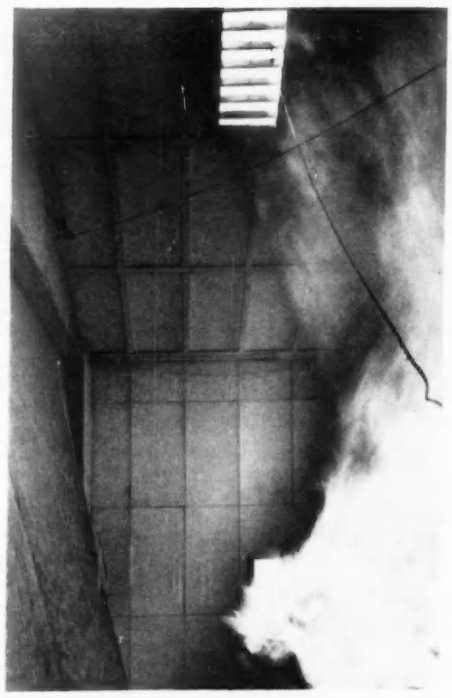
To protect the third bay of the building is a curtain woven from blue asbestos fibre with a metal strand interweave. The curtain is 20 ft. wide by 14 ft. 6 in. high and is suspended from a hollow steel roller supported by two steel stanchions. The bottom of the curtain is weighted with a taut chain. The sides of the curtain have guide wires sewn into the seams and a locking arrangement which operates when the curtain falls to the ground, thus ensuring that, while it may be drawn towards a fire by a difference in the air pressure, it is not sucked out of position. Escape flaps are incorporated in the curtain and these have weights to keep them in place. The fall of the curtain is operated by a fusible-link mechanism located on each side of the curtain. The links are designed to fuse at approximately 150 deg. F., but a hand winding mechanism permits the testing of the curtain at any time and its easy re-rolling. Above the curtain rail is a fire break of Asbestolux sheeting, right up to the roof apex; this forms an effective fire stop.

Roof ventilation is provided by three dual-purpose heat and smoke exhaust ventilators supplied by Colt Ventilation Limited, Surbiton, Surrey. Two of these, on opposite roof slopes, are in the fire compartment and represent 2 per cent. of the floor area of the compartment, and the third is in the roof on the protected or "cold" side of the curtain. These ventilators, which are designed for everyday use for normal ventilation, consist of gravity-opening louvres made from aluminium-alloy sheets. Normally, they are operated by a hand winch working a nylon-covered cable, but, in case of fire, they are opened by the melting of a fusible link, at 158 deg. F. These ventilators remove the risk of an explosion in a burning building by enabling superheated air to escape and the release of internal pressure generated as a result of the conflagration. The ventilators also allow all the smoke and much of the heat to pass out upwards, enabling firemen to approach close to the fire and fight it. In serious fires, the aluminium-alloy louvres begin to soften at 600 deg. F., and finally melt and fall out between 1,200 deg. and 1,500 deg. F., thus giving uninterrupted access to firemen fighting the fire.

In the actual test, carried out in our presence, two tons of old timber logs and some rubber tyres, soaked with 20 gallons of paraffin, were ignited automatically by push button from outside the building. It is stated that the total calorific value of the combustible materials was in the neighbourhood of 42 million B.Th.U., or an equivalent of 100,000 B.Th.U. per sq. ft. of the fire section. The fire began slowly but, in a very short time, the fire-alarm bell began to ring and very soon the temperature in the fire compartment had reached 150 deg. F., and the asbestos cloth curtain fell and thus isolated the area in which the fire had started. Dense smoke, largely produced by the burning of the old rubber tyres, was allowed to escape by the automatic opening of the two ventilators on the hot side of the asbestos curtain. Five minutes after the outbreak, thermocouple readings were taken and the air temperature at the apex of the roof in the fire compartment was 1,320 deg. F. and that at the tie-beam level in the fire compartment, 1,840 deg. F. The corresponding temperatures in the protected department were 520 deg. and 840 deg. F. respectively. After 10 minutes the fire was going very strongly and the temperatures registered at the two apexes were respectively 2,450 deg. and 810 deg. F., and at the tie-beam level 2,520 deg. and 1,590 deg. F. Corresponding temperatures, after 25 minutes, were (apex) 1,870 deg. and 1,080 deg. F. and (tie beam level) 1,800 deg. and 1,190 deg. F. After 30 minutes' duration, the fire was extinguished by a team from Pyrene Limited, working with portable appliances.

A short time after the fire had been extinguished duck-boards were pushed into the building and it was possible for the visitors to file through the structure. It was clear that the Cape Company's claim that, in spite of the severe conflagration lasting half-an-hour the building remained largely structurally undamaged, had been substantiated. The Asbestolux insulating board linings on the walls and ceiling were all apparently in place and, while some of the external corrugated sheets had suffered some damage and would need replacing, and the rectangular holes in the roof left by the melting out of the aluminium ventilator louvres would have to be covered up, the building was usable. Some articles on a storage rack on the cold side of the curtain had suffered damage, but a tin of baked beans appeared to be in good condition and its only noteworthy characteristic when handled was that it was quite warm to the touch.

To sum up, the purpose of the asbestos curtain and the roof ventilators is to isolate the fire and prevent it from spreading horizontally through the factory building.



The fire in the test building, representing three bays of a factory, is now well alight. The blue-asbestos cloth curtain operated by fusible-link mechanism has fallen to isolate the fire and the dual-purpose smoke and heat exhaust in the roof, also operated by fusible-link mechanism, has opened. The curtain is drawn out of the vertical by a difference in the air pressure but is weighted so that it cannot be sucked out of position.

DIE-CASTING IN MODERN INDUSTRY

Organised by the Syndicat Général des Fondeurs de France for the European Pressure Die Casting Committee, formed in 1953, the second International Pressure Die Casting Conference was held in Paris from May 20 to 24. Seven technical sessions were held, at which 17 papers were presented. Some of the points raised in several of these contributions are briefly summarised below.

DEVELOPMENT OF DIE CASTING

In a paper entitled "Development of Die Casting in Europe," Mr. R. Lewis Stubbs, director, Zinc Development Association, London, gave some statistics regarding the growth of the industry before, during and since the war of 1939-1945. He stated that, by 1950, the output of zinc die castings in the United States had reached 261,000 metric tons, and that of aluminium die castings 76,000 metric tons. In Europe some 21,000 metric tons of aluminium and 50,000 metric tons of zinc die castings had been made in that year. Of the 76,000 metric tons of zinc die castings produced in Europe in 1956, Great Britain had been responsible for 36,000 tons and France and Germany for 15,000 tons each. Of the European output of 59,700 metric tons of aluminium die castings in 1956, Great Britain had produced 14,700 tons, France 10,000 tons and Germany 14,000 tons.

In the major producing countries, the motor-car industry was by far the largest customer. For zinc die castings, however, there was a considerable variation in the weight of castings per vehicle, used by the motor-car manufacturers in different countries. British and American cars each carried an average of between 60 and 70 lb. of die castings; French cars carried about 30 lb.; German cars 25 lb.; and Italian cars about 20 lb. The other major uses of die castings in Europe followed a pattern different from that of the American industry, where the second major use was for household equipment. In Europe, light engineering and electrical goods occupied second place at present.

CHOICE OF ALLOYS

Speaking on the "Choosing of Alloys for Die Casting," Dr.-Ing. W. Wolf, of the Metallgesellschaft A.G., Frankfort-on-Main, Germany, said that the zinc alloys were still the most satisfactory and economical, at all events from the die-caster's point of view. Higher demands on the part of users, particularly in regard to corrosion resistance and fatigue strength, coupled with the attraction of lower weight and coinciding with the introduction of the cold-chamber process, had led to the development of aluminium alloys capable of being die cast, and later on of magnesium alloys. Magnesium

alloys were easier to cast than aluminium alloys and their density was lower. The pressure die casting of copper alloys was still somewhat restricted as they did not exhibit sufficient dimensional accuracy, while the life of the dies was short.

A drawback to aluminium alloys was their high gas absorption and oxidation, resulting in porosity and oxide inclusions. Difficulties were also encountered in the surface treatment of aluminium-alloy die castings. Electroplating was certainly possible but was seldom used, while anodising did not give a particularly pleasing appearance owing to streakiness in the oxide film. Parts used for decorative purposes were therefore usually either polished or painted.

In a paper entitled "Aluminium Pressure Die Castings," Dr.-Ing. C. Bücken, of Karl Schmidt A.G., Germany, dealt with the advantages of aluminium pressure die castings and answered some of the objections raised by various users. To the criticism that aluminium had a low modulus of elasticity and that the parts lacked stiffness, Dr. Bücken answered that this could be overcome by the provision of stiffening ribs. To the complaint that aluminium had a high coefficient of expansion, he answered that by the addition of silicon this could be reduced to negligible proportions.

In Germany, continued Dr. Bücken, only sports motor cars made any material use of aluminium and up till the present none of the passenger-car manufacturers had really studied the possibility of the use of light metals. Nevertheless, by the use of modern production methods and the judicious application of aluminium die castings, the weight of motor cars could be materially reduced. In Europe, where the weight: power ratio lay between 15 and 35 kg. per h.p., it was necessary, in order to improve acceleration and speed under modern traffic conditions to approach nearer to the American figure of from 6 to 10 kg. per h.p. Light-metal die castings could be used for the cylinder block, clutch and gear housings, pistons, and for such parts as wheels, hubs, brake components, fuel tanks, silencers, differential housings, driving shaft housings and accessories, steering boxes and accessories, and door frames.

ALUMINIUM IN ZINC ALLOYS

Mr. L. A. J. Lodder and Mr. K. P. Scott, of the Imperial Smelting Corporation, Limited, in their paper, "The Influence of Aluminium in the Zinc Die-Casting Alloys," discussed the significance of aluminium as an alloying constituent in the zinc pressure die-casting alloys. They stated that, some 20 years ago, the New Jersey Zinc Company had developed the Zamak alloys and, in terms of optimum mechanical properties, general stability and ease of casting, a level of addition of 4 per cent. of aluminium appeared to have been the best possible. The alloys were known as Mazak in the United Kingdom and long-term outdoor exposure tests had given results showing the excellent retention of the mechanical properties of these materials. Furthermore, extended humidity tests, carried out under somewhat searching conditions, had shown that zinc-alloy die castings which conformed with the rigid specification requirements had excellent outdoor durability. Despite these and other intensive investigations, no change of composition had been advocated and these alloys continued to dominate the field, and were being used on an increasing scale both in the United States and in Europe.

FINISHING TECHNIQUES

"Experiences and Problems in the Surface Treatment of Zinc and Aluminium Die Castings" was the title of a paper in which Mr. H. Ruegg described the finishing techniques applied to zinc and aluminium die castings at the works of Injecta A.G., Switzerland. He stated that the cleaning of the castings was carried out, according to circumstances, by mechanical polishing methods using wheels and belts, by sand-blasting and by barrel polishing. The phosphating process in which the articles were treated to give a rough, porous surface providing a good anchorage for subsequent paint application, was most suitable for zinc die castings. After thorough degreasing the phosphating was conducted in a bath heated to a temperature of between 90 and 98 deg. C., and containing zinc phosphate, free phosphoric acid, and zinc nitrate as an accelerator. The time of immersion was about two minutes and, after rinsing in cold water, the articles were plunged in hot water for a few minutes and then dried.

In electroplating there was an increasing tendency to demand minimum thicknesses of deposit which must be met in any part of the casting. Much help could be obtained by the use of auxiliary anodes, bi-polar electrodes and screens. These various techniques played an important part in chromium plating. At the Injecta Works, the chromium bath contained from 220 to 250 grammes of chromic acid per litre and the ratio of H_2SO_4:CrO_3 should be between 1·80 and 1·14. With a current density of from 30 to 50 amperes per sq. decimetre and a time of treatment of from 10 to 20 seconds, the deposit had a thickness of from 0·1 to 0·2 micron. The chief value of this form of plating was its appearance and it prevented the typical tarnishing of straight nickel plate.

The anodic oxidation of suitable aluminium die castings could be carried out in all cases in which the aim was to produce a corrosion resistant film rather than a decorative one.

DIE-CASTING MACHINE COMPONENTS

In a paper on "Some Problems in the Finishing of Zinc-Alloy Die Castings," Dr. J. Edwards, of the British Non-Ferrous Metals Research Association, stated that the Association had undertaken a detailed study of the properties of chromium electrodeposits with the aim of developing methods of depositing thick crack-free and bright chromium coatings. A report had already been published, by H. Fry, of work on the relationship between internal stress, microstructure and cracking. Subsequent work by the same investigator had led to changes being made in the usual chromic acid-sulphuric acid electrolyte which permitted the deposition, at normal temperature and current density, of low-stress deposits which were free from cracks up to the greatest thicknesses yet attained (0·005 in.). Outdoor exposure and accelerated corrosion tests had shown that deposits 0·0004 in. thick had extremely high corrosion resistance. Unfortunately, the deposits were dull and, for decorative applications, required to be polished. Further systematic and fundamental work was being undertaken in the hope of finding a method of plating such deposits in a bright form. If this were accomplished the effect on the decorative electroplating industry was likely to be profound.

In a paper "The Use of Spheroidal-Graphite Cast Iron in the Pressure Die Casting of Zinc and Aluminium Alloys," Mr. L. Oltrasi of the Societa Necchi, Italy, drew attention to the many applications which spheroidal-graphite cast iron had found in the construction of parts of die-casting machines. Thus, the material was used for crucibles for the melting or holding of alloys of aluminium or zinc in electric resistance furnaces; for plungers, both for cold-chamber aluminium and hot-chamber zinc machines, for goosenecks for hot-chamber machines and for bolsters and holding blocks for dies. For use for crucibles, plungers and goosenecks, the average life of spheroidal-graphite iron was much greater than that of grey iron, while, for bolsters and die blocks, spheroidal-graphite iron provided a material having adequate elongation and resistance to shock and, in addition, better machinability than steel.

In the course of his paper "Steels for Pressure Die-Casting Dies," Mr. K. I. Bengtsson, of Aktiebolaget Bofors, Sweden, stated that all authors agreed that the steel used for pressure die-casting dies must have a high tensile strength at elevated temperatures. The carbon content was normally from 0·25 to 0·40 per cent., but preferably from 0·25 to 0·30 per cent. A silicon content of about 1 per cent. was sometimes used, but in association with other alloying elements. The normal content of manganese was between 0·20 and 0·60 per cent. Some chromium was present but additions of nickel were not very often made to die-casting die steels. The effect of molybdenum on the tensile strength at elevated temperatures was very marked. The importance of molybdenum, up to 2 per cent., was increasing as a substitute for tungsten. The latter, however, was still most frequently used to increase the hot tensile properties of hot-working steel than any other element. This effect was approximately proportional to the percentage up to about 10 per cent. Some vanadium was added to almost all grades of hot-working steels to inhibit grain growth. For a hardening temperature of 1,100 deg. C. about 0·40 per cent of vanadium was a minimum.

In the matter of future metallurgical trends, the importance of tungsten was decreasing to the benefit of molybdneum and the importance of cobalt and perhaps of titanium would probably grow, the latter taking the place of the more expensive element vanadium.

It may be of interest to recall that the first International Pressure Die Casting Conference was held in London, in October, 1954. It was organised by the European Pressure Die Casting Committee with the help of the Zinc Development Association. The proceedings of the Conference were published last year and copies are still available, price 7*s*. 6*d*., post free, from the Zinc Development Association, 34 Berkeley-square, London, W.1.

COUNTERING CORROSION

With the object of illustrating the aims, objects and achievements of the Corrosion Section of the Chemistry Department of the British Iron and Steel Research Association, an exhibition was held during the last week in May at the Association's London laboratories, 140 Battersea Park-road, S.W.11.

Upwards of 30 exhibits of apparatus, series of specimens, instruments and items of equipment were displayed in various laboratories and rooms of the Department. Among the many objects of interest to engineers were exhibits showing the beneficial effects of low-alloy additions on the corrosion resistance of steel wires exposed in an industrial atmosphere. Exposure tests have shown that a steel containing about 0·3 per cent. of copper is roughly 80 per cent. more resistant to atmospheric corrosion than ordinary mild steel, and that low-alloy steels containing about 1 per cent. of chromium, in addition to the copper, are three times more resistant. Spun cast-iron pipe specimens, both left bare and coated with bitumen, aud dug up after burial in different soils for ten years, indicate that the time and trouble taken to coat them is well worth while.

The special equipment on show included a horizontal rotor revolving in a drum filled with sea-water or other corrosive medium. This machine is designed for tests on specimens immersed in liquids and moving at rates of up to 15 knots. In another room, was an automatic apparatus for stress-corrosion tests, constructed under a Ministry of Supply contract. This incorporates a salt-spray and a heating device and the apparatus will accommodate some 120 specimens.

In a nearby constant-temperature room, storage tests and various experiments are conducted at a constant temperature of 70 deg. F. and a constant relative humidity of 55 per cent. Other interesting equipment on view was apparatus for measuring sulphur dioxide and smoke concentration in the atmosphere, and apparatus for conducting laboratory tests on heat-resisting paints.

OPERATION AND IMPROVEMENT OF HYDRAULIC SYSTEMS

The steady growth of the use of hydraulic plant in industry, and particularly in the steel industry, prompted the British Iron and Steel Research Association to organise a conference on the subject. This was held at Ashorne Hill from March 26 to 28, 1957, and under the chairmanship of Mr. W. M. Larke, of Stewarts and Lloyds, Limited, ten papers were delivered to an audience of over one hundred and fifty, representing steelworks engineers, and manufacturers, designers and research workers in the hydraulic field.

The first paper presented, by Mr. R. L. Willott, of John Summers and Sons, Limited, on "Works Hydraulic Installations," was based on the experience of his own company, where hydraulics were first introduced in 1905 and considerably extended from 1949 onwards.

After describing the many teething troubles which had to be overcome, the speaker compared the state of development of modern hydraulics with that of modern electronics. He felt that the difficulties which arose were largely due to inexperience. Turning to specific points, he made a strong plea for limiting the working pressure to 500-1,000 lb. per sq. in. to obtain robustness and reliability, although higher pressure systems gave faster operation and greater compactness.

INSTALLATION TROUBLES

On the subject of installation layout, the speaker felt that there were only two alternatives, either to complete the design in the drawing office, or to have an expert build on the spot. Both had their difficulties, but it was in faults of layout that most troubles arose.

With regard to the design of fittings, Mr. Willott expressed an abhorrence of clevis-mounted cylinders. He felt that if oscillation were inevitable, piston rods should be employed at both ends of the cylinder. He was also troubled about the lack of provision for shock loads. The design of tanks and filters, too, left much to be desired. Tank covers in particular were seldom replaced after inspection, and a simplified dirt-proof design was needed. Even so, it was not at all clear how so much dirt got into hydraulic systems.

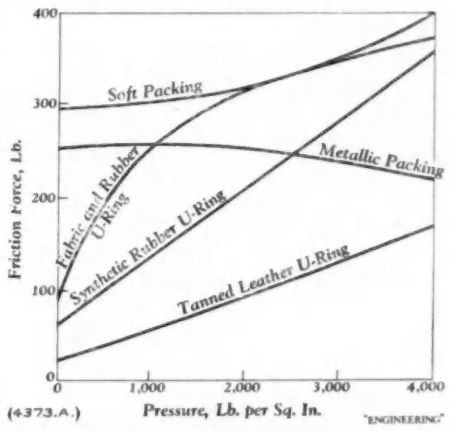
In conclusion, he did not feel that great complication in the form of hydraulic servo operation was usually necessary, and preferred to see the simplest possible arrangement in a steelworks system.

The paper by Mr. F. E. C. Probyn, of Richard Thomas and Baldwins, Limited, also provided an account of somewhat similar steelworks' experiences. The Ebbw Vale Cold Mills, commissioned in 1938, were equipped with oil-hydraulic systems for reel strippers, coil lifts, electrolytic cleaning lines, and other plant. The hydraulic layout consisted of two main systems involving extensive pipe networks, much of which was inaccessible, and almost immediately after installation serious trouble was experienced.

Oil leakage, due to bad pipe connections and insufficiently robust hose connections, quickly reached staggering proportions. A changeover to a 10 per cent. solution of soluble oil and water damaged the large-capacity radial-ram high-speed pumps and these had to be replaced by conventional three-throw pumps. The poppet control valves had suffered pitting of the stems by pig-skin packing during storage, and the increased friction caused sticking in the "open" position.

Mr. Probyn then gave details of some hydraulic installations at Ebbw Vale since 1948. Equipment installed served tandem and temper mills, ram and fork tractors and a butt welding machine. Also, hydraulic drives were being installed on a continuous galvanising line. All these schemes were oil-hydraulic, generally with pressures of 800 lb. per sq. in., supplied by vane pumps and controlled by directly operated spool valves. Pilot-operated valves were also used and, for high pressures, high-speed multi-ram pumps were employed. Chromium plating for rams was specified to minimise wear on packings.

Three main conclusions arose from his firm's experience of hydraulic systems, namely, the need for simplicity in design; good staff training; and correct installation during initial building. Neglect of the last was the direct cause of much early trouble, when badly fitted pipes and unflushed systems led to damaged valves and pumps.



Reciprocating seals are widely used in hydraulic machinery and the friction of different materials employed varies widely.

The trend at the Ebbw Vale works was to look for improved performance, lower initial cost, and easier maintenance by the increased use of hydraulics. The management were convinced that there were many cases of electrically-driven steelworks plant which could be improved by a change to hydraulic operation.

INGRESS OF DIRT

In the subsequent discussion on the two papers, it was clear that the problems arising from the piping systems involved in steelworks hydraulics loomed very large in the experience of users. There was broad agreement that the preparation of elaborate drawing-board schemes was a mistake, and that the provision of a simple schematic layout which could be left to piping experts to install in the light of local conditions was probably the best procedure. Complaints of line-shock, leakage and similar piping troubles were, it was generally agreed, often basically attributable to poorly-designed layouts or inexpert installation. Bag-accumulators were suggested as a safeguard against line-shock by one speaker but, fundamentally, a trouble-free system rested on sound original design.

Mr. Willott's remarks on filter and settling tank design were echoed by other speakers. It was suggested that by introducing perforated baffles in such units, dust and dirt would settle out of circulation. The practice of manufacturers in designing tanks with covers fastened by large numbers of bolts also came in for criticism. Too often this resulted in the fitter leaving the lid off—thereby aggravating the very trouble the apparatus was designed to obviate.

Replying to these points, Mr. Willott asked manufacturers to design apparatus incorporating sedimentation sumps and both coarse and fine filters, making any shifting of the lid unnecessary. The ideal, it was suggested, would appear to be a completely sealed pressurised system.

Some of the manufacturers' representatives present pointed out that improved designs were, indeed, available; one such design without a lid provided access through the side, which had to be properly secured before the unit could be filled.

Several speakers entered a plea for better component design by manufacturers, the suggestion being that component design should be envisaged much more closely in relation to the piping layout and the hydraulic system as a whole. On the other hand, the steel industry should itself "raise its sights" and demand better performance standards; the conference members' preoccupation with leakage troubles was pointedly contrasted with the experience of the aircraft industry, where very high performance standards—and, above all, no leaks—characterised the wide use of hydraulic techniques. A speaker from the steel industry said that most steelworks had perfectly satisfactory water-hydraulic systems, and suggested that oil-hydraulic systems might be employed for rapid control of existing water systems.

The problems of tube size and the difficulty of getting tubes with the correct outside diameter were also aired. A manufacturer's representative replied that a 4 in. "tube" meant that the outside diameter was 4 in., but that a 4 in. "pipe" meant that the bore was 4 in. A tube could be ordered to diameter and thickness, to diameter and bore, or to bore and thickness. Mean diameter and mean thickness were always implied. As examples of makers' tolerances, he quoted plus or minus 1 per cent. for hot-finished tubes, and plus or minus 0·008 in. on 4 in. diameter cold-drawn tubes. The ovality of tubes made them unsuitable for use as cylinders which should preferably be machined from the solid.

STANDARD COMPONENTS

Mr. R. G. Hamilton, of Stein Atkinson Vickers Hydraulics, Limited, presented a paper on "Standard Components for Oil-Hydraulic Power in Steelworks," which reviewed contemporary practice in the use of standard units for hydraulic circuits. He quoted some examples of application, including the case of a forging press where control involved the movement of a large valve. A compact, easily installed and relatively inexpensive solution had been obtained by the use of a standard heavy-vehicle steering booster.

A rotary hearth furnace for heating billets for a tube extrusion plant, with charging and discharging machines, had been hydraulically equipped. The lifting and clamping motions were performed by cylinders, and the run-in by fixed-displacement constant-torque hydraulic motors driving the carriage through racks and pinions and a reduction gear. The circuit provided infinitely variable speed, with two-stage hydrodynamic braking, to control the stopping position accurately.

A plant for the production of railway disc-type wheels had been built with completely hydraulic operation for all the following functions: (i) lifting billets from a conveyor, turning them through 90 deg., and lowering them into a furnace conveyor; (ii) opening and closing the furnace doors; (iii) charging and discharging; (iv) hot billet conveyance; (v) loading and unloading into a "rough" forging press; (vi) rolling of wheel form and (vii) unloading from the final "coining" press.

In the discussion following Mr. Hamilton's paper, it was generally felt that whilst the use of standard units would be a considerable advantage in steelworks, it was sometimes necessary to use non-standard equipment, particularly cylinders, control valves, and pipe-lines. There had been considerable reluctance on the part of some manufacturers to design such non-standard equipment. It was, of course, realised that "one-off" valves were not always economic, but it was possible that the range of standardised equipment could be extended.

A paper "Precision Control of Hydraulic Forging Presses" was then presented by Mr. F. H. Towler of Towler Brothers (Patents) Limited, giving a brief survey of the various hydraulic systems for forging presses, with par-

ticular reference to methods of controlling the size of the finished forging within precise limits. He traced design development from Allen's " crank hydraulic " press of 1886 which, although based on the fallacy that water is incompressible, did nevertheless operate fairly satisfactorily.

DIRECT PUMPING ADVANTAGES

Controlled displacement of the press cross-head by a crank-operated or intensifier plunger making predetermined strokes, was subject to considerable error due to the compressibility of the liquid. Positive stops were time-wasting and required the press to operate at full load at every blow. Control by a tappet-operated cut-off valve involved (*a*) a valve which operated consistently in a fraction of a second, and (*b*) a reasonably constant rate of penetration, not varying greatly with load. Condition (*b*) was difficult to achieve with air-loaded accumulators, or steam or air-loaded intensifiers, but was met by a direct hydraulic system. Moreover, oil and hydraulic pumps could give higher efficiency, and 20 per cent. greater penetration speed could be obtained for the same driving energy. The elimination of pipe-lines and the mounting of the decompression valve on the press cylinder, discharging directly into an " anti-surge " tank, were essential for rapid decompression.

The direct-pumping method presented much smaller burst and fire hazards than accumulator systems, and there was no reason why such an oil system should be any more serious a hazard than an oil-fired furnace or a large quenching tank. Where an anti-surge tank was fitted on top of the press, an emergency dumping valve should be provided to discharge the oil into an underground tank. Non-inflammable fluids were expensive and not very successful. They also reduced the working life of high-speed pumps.

A method of recording the performance of forging presses had recently been developed by B.I.S.R.A. using a twelve-channel oscillograph. This was being employed to obtain accurate performance details on a number of presses.

In conclusion, Mr. Towler expressed regret at the reluctance of British users, in contrast to those on the Continent, to install direct-pressure systems which, he felt, gave the best control and represented the most economical way of employing the force involved.

It was clear from the subsequent discussion that there was some agreement that forging hydraulics in this country were not entirely satisfactory. One of the reasons, it was suggested, was that forge operators were remarkably unaware of the true performance factors of the plant they were using. In reply, Mr. Towler suggested that it was a reproach to the steel industry that forging work should be conducted on *ad hoc* principles, without a clear idea of the relevant efficiency and performance factors. If ever an argument was wanted in favour of research associations, one had it there; to improve on existing practice, it was first necessary to know the precise operating data.

The speed of manipulation in relation to forging efficiency was also raised by speakers. Faster press operation, with increased penetration rate, was certainly important, but this still left unaffected the manipulation, or " ingot-free," time. The general standard of manipulative practice in this country was both primitive and slow, and there might be a considerable field for a much wider application of hydraulics to this aspect of forging. The speed of raising the press ram might also be increased to improve performance; the " raising " period was, after all, " dead " time. The technique developed by B.I.S.R.A. for recording press performance would enable the detailed recording of the sequence of all the events included in the forging operation itself, the variation in pressure and the movements of the cross-head and of the ingot between strokes.

HYDRAULICS AND ELECTRICITY

Mr. F. B. Levetus, of Keelavite Rotary Pumps and Motors, Limited, gave a paper " Modern Pumps and Hydraulic Motors and their Application." He reviewed the range of machinery currently available, and indicated the most favourable circumstances for the employment of different types. Hydrostatic drives offered formidable technical advantages, and in most cases a suitable combination of hydraulic units could be chosen which would cost less than an electric drive. He produced figures to show the relative cost of different types of hydraulic pumps and motors.

The two fundamental features in favour of hydraulic drives were probably the ability to control torque and speed separately under all conditions, and the extremely low moment of inertia of rotating parts. Independent control of torque and speed enabled hydraulic drives to be used to ensure exact control of coiling tensions of strip or foil, and hydraulic integrating controls could be applied to rotary or linear motions capable of very high speed.

Despite their simplicity, Mr. Levetus emphasised that successful operation called for stringent control over circuit operating conditions. Oil must be kept scrupulously clean, and the circuit engineered to avoid all shock loads.

He concluded by holding up a 10 h.p. hydraulic motor on the palm of his hand, and inviting the audience to compare this with its electrical counterpart.

Commander J. I. T. Green (R.N. Ret.), head of B.I.S.R.A.'s Mechanical Engineering section, outlined the work B.I.S.R.A. had so far undertaken in the hydraulic field, in a paper entitled " Problems Relating to Steelworks Hydraulics."

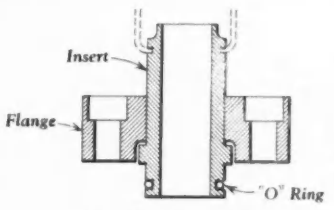
Consideration was being given to the hydraulic control of roll gap. A method for investigating the performance of forging presses had also been developed, already referred to by Mr. Towler, and a study was now being made of the uses of hydraulics in the automatic position control of presses and manipulators.

A number of visits had been made to steel firms and to manufacturers to discuss hydrostatic problems in general, and it was apparent that there was a wide divergency in the extent to which hydraulics had been developed in the steel industry. The type of hydraulic fluid, working pressures, control of the movement of large masses requiring rapid acceleration and deceleration, the uses of fixed-capacity pumps, the testing and selection of couplings and valves and hydraulic servo-mechanisms, were all problems in which the steel industry required guidance. It was hoped that B.I.S.R.A. would be able to build up sufficient background knowledge and staff to assist the steel industry and manufacturers with these problems. Turning to the aeronautical equipment suppliers at the conference, Commander Green concluded that steelworks machinery would have to be " flight-tested," so to speak, for 10,000 hours if it was to be acceptable.

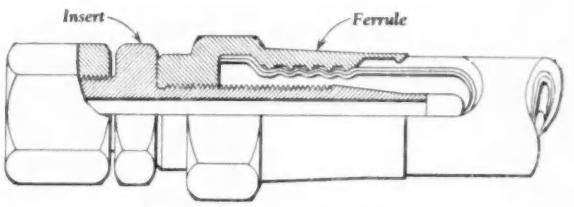
Mr. Anthony Vickers, of the Fluidrive Engineering Company, Limited, spoke on " Fluidrive and its Application to the Iron and Steel Industry." He traced the development of the hydrokinetic principle of transmitting power from the " Föttinger Transformator," which appeared in Germany in 1905, through its marine applications to its subsequent widespread adoption by the automobile industry. He described the design principles involved in the two main types—the automotive or traction coupling, and the variable-filling or scoop-tube type, and provided a technical analysis of their performance characteristics.

He summarised the advantages of the Fluidrive as follows: The " traction " type enables a squirrel-cage motor to develop peak torque for accelerating the load smoothly, the rate being readily adjusted by varying the filling of oil. The torque transmitted is limited to a predetermined safe value, even if the drive is suddenly stalled or the motor plugged. Electrical heating is reduced owing to the more rapid acceleration of the motor and the lower current taken, and flexibility of control is increased Where variable-speed motors are used, both electrical and mechanical maintenance costs are considerably reduced.

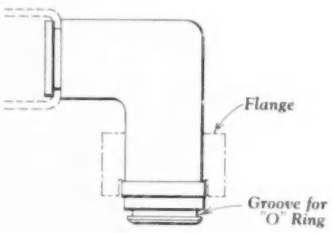
The scoop-control type, in addition to the above, also provides infinitely variable speed regulation over a useful range depending on conditions. The motor can run continuously, complete connection and disconnection of the drive being effected by operating the scoop. Various types of control can readily be applied, including automatic tension-limiting control for heavy iron ore conveyors.



Slip Flange Connector with Spigot Mounted "O" Ring



Modern Type Hose with Steel Ferrule



90 Deg. Angle Connector with Spigot Mounted "O" Ring

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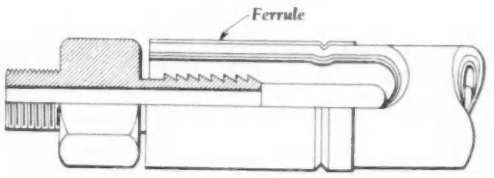


Pre 1939 Type Hose with Steel Ferrule

"ENGINEERING"

Leakage is one of the major troubles encountered in work's hydraulic plant, and a new type of flanged joint with brazed ferrules has been developed. Nylon rings also offer considerable advantages.

LEAKS AND SEALS

A stimulating talk referring to the difficulties in battleships caused by leaking pipes was given by Lieutenant D. H. Cameron of the Admiralty Engineering Laboratory. His paper, entitled " Nylon Pipe Joints for Use in Hydraulic Services up to 3,000 lb. per sq. in.," was presented by permission of the Admiralty.

An account was given of the old and new types of joint assembly, and the results of repeated pressure and vibration tests on each. Although tests were not entirely complete, it appeared that a ring machined out of some form of extruded nylon might be found to have sufficient advantage eventually to replace the old

copper diamond rings. Incidental to these tests was a new type of flanged joint having ferrules brazed to the pipe ends to be joined.

Dr. D. F. Denny, of the British Hydromechanics Research Association, prefaced his paper, " Work on Seals at the Hydro-mechanics Laboratory ", with a short talk on the work of his Association.

The B.H.R.A. was formed in 1947 and now has a staff of about 40, half of whom are technical. Research was being conducted on a variety of problems, including fundamental fluid mechanics, hydraulic transport of solids, the design of seals, hydraulic transmissions and the use of scale models to study flow problems encountered in civil engineering. Roughly two-thirds of the programme was co-operative research of direct interest to a wide variety of firms, and one-third was sponsored, having limited application. Advisory and information services were also available.

In his paper, Dr. Denny stated that it was only under particularly arduous conditions, as might be encountered in the steel industry, that provision of adequate seals presented a problem. Until recently, small leaks had been tolerated, but to-day a leak-free system was often regarded as absolutely essential, and designers found themselves handicapped by the paucity of background knowledge available on this subject.

The B.H.R.A. was therefore giving considerable emphasis to fundamental research, although a limited amount of test work on rubbing seals was also carried out. Laboratory facilities allowed for tests at pressures up to 10,000 lb. per sq. in., temperatures ranging from − 40 deg. F. to + 200 deg. F., and at shaft speeds up to 6,000 r.p.m.

Comparing reciprocating and rotary seals, Dr. Denny said that one could almost generalise and say that while the characteristic features of reciprocating seals were high pressures and a tendency to leak, in the case of rotary seals the features were high speeds and a tendency to overheat. The paper outlined the main types of seals available for hydraulic applications and discussed how and where they might best be used.

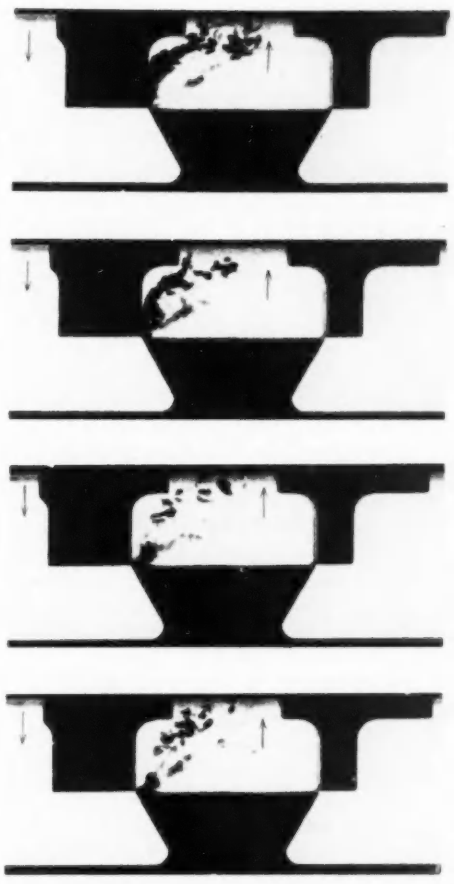
The speaker concluded by emphasising the opportunity and need for research. What was wanted was an adequate fund of published design data. Research, allied to development, would markedly improve the performance of sealing devices and extend their useful range to include those difficult applications so frequently encountered and so troublesome to solve.

A paper on " The Work of the Fluid Mechanics Division of the Mechanical Engineering Research Laboratory, D.S.I.R.," was delivered by Mr. D. Firth.

After tracing the historical development of M.E.R.L., formerly a part of the National Physical Laboratory, Mr. Firth explained that the Division's work could be split into three groups: basic research; applied research and development; and investigations for industry and governmental organisations. Hydraulic problems involving both oil and water media were studied in laboratories equipped with apparatus representing the latest scientific advances developed both in Britain and abroad.

To illustrate the scope of the work undertaken, Mr. Firth detailed some typical examples. Prominent among them was the fundamental problem of cavitation, its effect on performance, and its potential as a source of damage due to the " implosion " of bubbles in the hydraulic fluid. The minuteness of these implosions made it possible for the forces involved to affect " soft " grains in the steel surfaces concerned and if, for example, seven or eight such implosions occurred on the same site, a fatigue effect could follow. By giving critical surfaces work-hardening treatment, the effect of cavitation could be considerably alleviated. Stainless steel (18/8) appeared to be the most suitable grade for use in likely cavitation areas.

Properties of hydraulic fluids were fundamental to component performance. Although viscosity, bulk modulus and specific weight were important,



High-speed photography is a useful tool in the study of turbulence, as for instance at the closing of a valve.

the free-air content of the oil affected them all, and much attention had been given to measuring it. Laboratory tests had shown that total air content during a day's run could vary from 3 to 18 per cent.

High-speed photography had been used to study valve performance on positive displacement pumps, together with transient tests using electronic units specially developed in the laboratories. Much information had been gathered on the variation of discharge coefficient with stroke, speed and flow angle.

Mr. Firth emphasised the importance of the laboratory's instrumentation section in developing new test apparatus. For measurement of large water flows, for example, special apparatus had been designed, e.g., a point velocity meter, a salt velocity flowmeter, and a propeller flowmeter. This latter development recorded automatically the rotational velocity of up to 21 propeller current meters, using electro-mechanical and photographic techniques. Salt velocity flow-measurement was achieved by timing the passage of a slug of conductive water between two electrodes.

IGNORANCE OF RESEARCH FACILITIES

Attention was also drawn to the facilities for sponsored research provided by the laboratories. These were of particular importance to firms in the hydraulic industry who had only limited resources for research. A valuable alternative was for a firm to second representatives to the laboratories to undertake individual research under the guidance of the staff. This had the added advantage of familiarising the industry with modern research equipment and techniques. Test results were confidential to the firm concerned.

Mr. Firth concluded with a plea to manufacturers, designers, and users, to make greater use of research facilities. The laboratory should be regarded as a service to industry, and he assured the conference that the laboratories liked nothing better than to be used.

It was apparent in the discussion following both Mr. Firth's and Dr. Denny's papers that manufacturers and steelworks engineers alike were impressed by the facilities provided by the various research bodies, of which many of them had previously been unaware. One speaker, while paying tribute to Government enterprise in providing and equipping laboratories, suggested that it was a pity that insufficient funds were provided to staff the laboratories to their full capacity, thus restricting the volume of research. Nevertheless, such organisations as B.I.S.R.A., M.E.R.L., and B.H.R.A., had a great deal to offer to industry, and he appealed for greater use to be made of their services. Component design tended to be empiric, and in illustration of this the speaker quoted the design of a pump produced by his firm many years ago. Originally it was rated at 350 r.p.m., but successive experiments had shown that the design worked quite satisfactorily at 750 r.p.m. and even as high as 1,500 r.p.m. However, the reasons why the design was such a practical success were still not known. Manufacturers had neither the time nor the facilities to discover precisely why machines or components worked satisfactorily, and any alteration from an originally successful design presented serious risks. The research associations, by elucidating these fundamentals, could provide that exact data which was necessary to put design on a scientific basis.

These remarks were echoed by another speaker, who stated that the conference had been invaluable to him in establishing a better understanding of the facilities provided by the associations, and of the practical value of their " long-term " approach. The practice at, for example, M.E.R.L., of providing facilities for firms' representatives to work at the laboratories not only went some way towards alleviating staffing difficulties, but also provided a valuable liaison between industry and research.

In summing-up the results of the conference, the chairman stated that perhaps its most important achievement was in laying the foundations of a better understanding between the manufacturer of hydraulic plant, the user, and the research worker which would unquestionably be to their mutual advantage. He drew attention to the fundamental problem of disseminating knowledge, a matter of great importance to the industry. There was no doubt that much valuable information on hydraulics from both within and without the steel industry was not reaching the people to whom it would be of value. There would appear to be a case for the compilation of a " manual of good practice " covering design, installation, and maintenance. This might possibly be undertaken by B.I.S.R.A. in conjunction with the research associations and manufacturers.

Certainly the conference would have one immediate and positive result in showing where expert help on hydraulic problems could be obtained. A practical point which had emerged very clearly was the desirability of keeping hydraulic systems as simple as possible in the first instance. Once the reliability of such systems was established, more complicated control methods could be contemplated. The trend which was discernible towards packaged equipment and standard units could simplify installation and considerably reduce maintenance problems.

It was clear that the steel industry could raise maintenance standards by greater attention to training. In this connection the " manual of good practice " previously mentioned would be of direct value. Hydraulics could play a great part in the rapid development of remote control and the automatic equipment necessary to meet the great expansion programme planned for the steel industry. After thanking the organisers and contributors to the conference, the chairman expressed the hope that it had stimulated creative thought which would, in due course, be followed by creative action.

SIMULATED FLIGHT TESTING OF AERO ENGINES

By Hayne Constant, C.B.E., F.R.S.*

Through the courtesy of the Stephenson Engineering Society of the University of Durham, we give below the main text of the Stephenson lecture presented at Newcastle-on-Tyne on December 3, 1956. In this lecture, Mr. Constant describes the evolution of aero-engine test facilities. With the advent of the subsonic gas-turbine engine, the simple plant which served for testing piston engines was no longer adequate, and it was superseded by individual component test rigs supplemented by complete engine tests in flying testbeds. These methods in turn have become inadequate now that aircraft speeds are well into the supersonic region, and test facilities for reproducing the air-flow pattern and conditions of pressure, temperature and velocity at very high altitudes, and of simulating icing conditions, are now essential. Such facilities are now under construction, and in partial use, at the National Gas Turbine Establishment, Pyestock.

Two subsequent articles will describe in detail the new facilities and the uses to which they will be put.

From the earliest days of aviation there has always been the need to know just how much power the engine was capable of developing under all conditions of flight. Everyone, of course, knew that the power of any heat engine would diminish the higher it was taken up into the air, for the simple reason that the engine depended for its power on its consumption of air, and the air available to it became less as the height at which it was flying was increased. But no one knew the precise law connecting engine power and altitude, and various guesses were made about the relative effects of air pressure and density in determining the indicated horse-power of the engine. This lack of knowledge was gradually corrected in the period between the two world wars by the erection of plants which simulated conditions in flight, and enabled us to subject the engine—which in those days was a piston engine—to conditions very similar to those which it would actually encounter when installed in an aeroplane.

In essence a plant of this sort consisted of a refrigerator which supplied air to the intake of the engine at the pressure and temperature appropriate to the altitude at which flight was being simulated; and an exhauster which sucked away the engine exhaust and maintained the engine back-pressure at the pressure corresponding to that altitude. This kind of plant worked very well and gave consistent and reliable results. As the forward speed of aircraft in those days was only a few hundred miles an hour, the temperature and pressure rise in the intake of the engine was small, and the temperature and pressure at the entry to the engine never rose significantly above those under static conditions on the ground. Moreover, it was not necessary accurately to simulate the flow pattern of the air entering the engine, as the engine was not an aerodynamic machine and was not appreciably affected by considerable changes in this flow pattern.

After the last war the era of the gas-turbine began. We were immediately faced with the old problem of how to predict the performance of the new engine in flight. There were a number of significant differences between both the engines and the aircraft before and after the war which made an attack on the problem much more difficult.

In the first place, a propeller gas-turbine, taking a lot of air for internal cooling, requires five times as much air per horse-power as does a piston engine, so that on these grounds alone a testing plant would be five times as expensive. Moreover, because of the increased speed of aircraft, the power required from engines has greatly increased, so that the total air consumption of present-day propeller turbine engines is not five times, but nearer thirty times, as great as in pre-war piston engines. The change to the jet engine makes an even greater contrast, for the jet is being built in even larger sizes and is a voracious consumer of air. When flying at the speed of sound, for example, a modern jet engine would consume air about one hundred times as fast as would a 1938 brand of piston engine flying at its usual subsonic speed.

* Director, National Gas Turbine Establishment.

COMPONENT TESTING

It is easy to appreciate, therefore, that immediately after the war there was considerable reluctance to construct a plant capable of testing gas-turbines under simulated flight conditions. This reluctance was fortified by the fact that the gas-turbine lent itself much more readily than did the piston engine to a process of analysis based on the testing of components. It is, of course, true that the piston engine also can be split up into its carburettor, supercharger and a number of single-cylinder units, but unfortunately in the multi-cylinder engine the interaction of the cylinders on each other due to pressure pulses in the intake and exhaust systems make it difficult to predict accurately the effect of combining a number of cylinders. Even if we could carry out altitude tests on a single-cylinder unit and deduce from the results what a multi-cylinder engine would do, owing to the effects of intermittency we should still be in difficulties when we tried to deduce, from the results of supercharging tests on the single-cylinder unit, the effect of adding a supercharger to the complete engine.

In the gas turbine, however, when the engine is operating correctly all the flows are steady and there are no intermittencies, transients or fluctuations when running at constant speed. (We are considering, at the moment, the performance of the airflow as a whole, and are not concerned with the small-scale pulsations due to wakes and resonances which result in local vibrations.) Taken as a whole, the process is a continuous steady one so that it is possible to isolate each of the three major processes of compression, combustion and expansion and consider them separately. We can, therefore, break down our testing into a study of the compressor by itself, driven by an independent source of power (Fig. 1); of the combustion chamber by itself, fed by air from a plant compressor; and of the turbine by itself, fed by hot

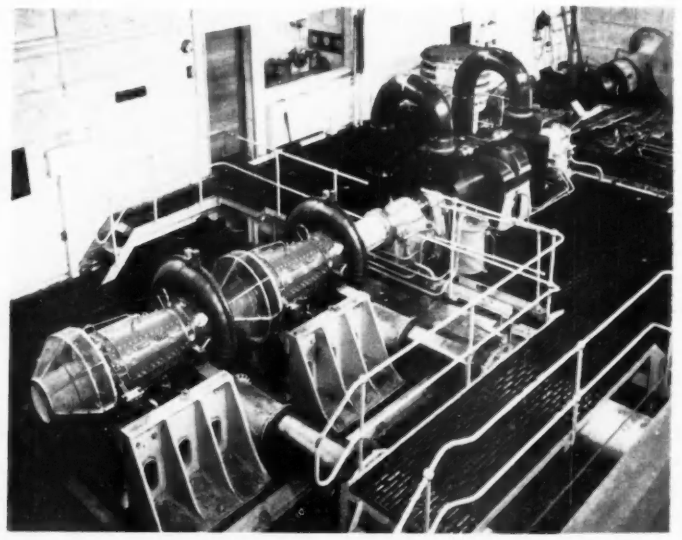


Fig. 1 (right) Plant for testing compressors at the National Gas Turbine Establishment; the compressor, in this case a Proteus unit, is driven by an independent source of power.

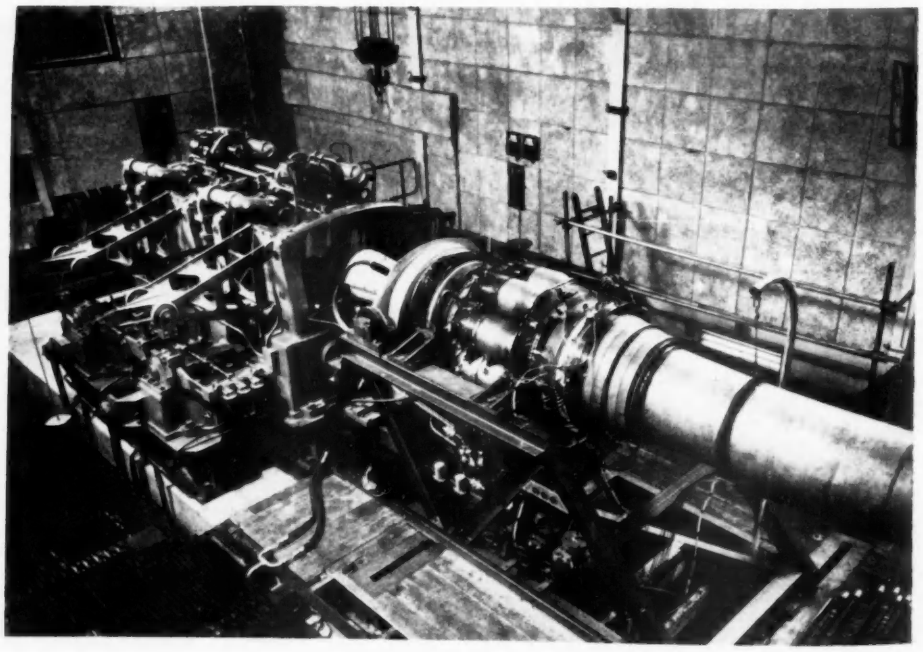


Fig. 2 (below) An Avon turbine on test at N.G.T.E.; fed by hot or cold air from a plant compressor, its power output is measured on a dynamometer.

Fig. 3 Engine performance estimates derived from component tests are checked by installing a complete engine in a flying testbed. Here, a Conway bypass turbojet is mounted below the belly of an Ashton flying testbed.

or cold air from a plant compressor and having its power output absorbed by a dynamometer (Fig. 2). We can even go further, if we wish, and split each of the components into sub-components and test, say, a quarter of the combustion chamber or one stage of the compressor separately.

By techniques such as these, guided and intepreted by the principles of non-dimensional similarity, it has proved possible to make comparatively inexpensive tests on the components of an engine under conditions simulating those to which they would be subjected in flight, and to deduce from these tests how the engine as a whole would behave when all the components were assembled together to form that engine. Great precautions have to be taken to ensure that the end conditions are correct; for example, the temperature, pressure and velocity of the air, and the distribution in space of these variables at entry to the combustion chamber, when this is being tested, must be arranged to simulate the conditions obtaining at exit from the compressor during the compressor tests. If these precautions are taken, we can deduce how the engine itself will behave when in an aircraft flying at speed at some great height under steady conditions.

It has been possible in the past to check the accuracy of these predictions by installing engines in fully-developed aircraft specially adapted for use as flying testbeds, in which an elaborate equipment of instruments has made practicable the accurate measurement of the engine's performance (Fig. 3). Flying testbeds have indeed enabled an assessment to be made of the dynamic behaviour of the engine in flight, under conditions of acceleration and deceleration. These transient conditions, due in the main to sudden movements of the pilot's throttle, cannot be predicted with certainty from a study of component performance, and the use of a flying testbed has been essential to enable the operation of the engine to be fully cleared before it is installed in a new experimental aircraft.

For these reasons we were content, in the earlier days of the gas-turbine, to rely on the testing of components to tell us how an engine behaved at altitude, and did not construct a special facility to test the complete engine under the conditions which it would experience in flight.

ENGINES IN SUPERSONIC FLIGHT

During recent years the situation has again begun to change. We have started to enter the region of supersonic flight. At first the engine hardly appeared to notice the difference. Subsonic intakes of simple pitot form were used and the engines were jets designed for subsonic flight. We are now, however, beginning to probe deeper into this region and the first intimations of trouble to come have already been received.

A system of propulsion for an air-breathing heat engine such as a jet-propulsion gas-turbine involves a number of components. The first of these is an intake whose function is to reduce the velocity of the air as it flows towards the engine and convert as much of it into static pressure as possible. This air then passes into the compressor where it is further compressed.

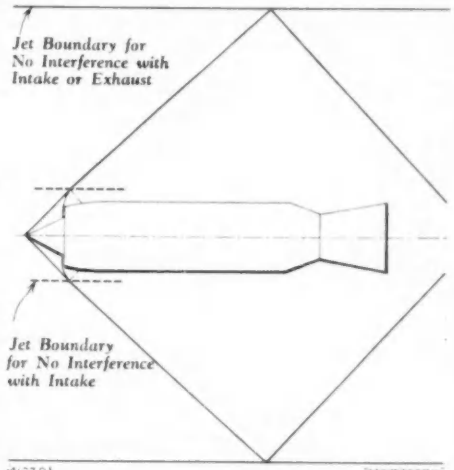


Fig. 4 The shockwave from the nose of the engine is reflected from the walls of the test cell. To avoid interference with the pod or unmixed wake, which would be necessary if complete flight simulation were aimed at, a very large diameter cell would be required. It is, however, possible to obtain satisfactory results from partial simulation by ensuring only that shock wave reflection does not interfere with the intake flow.

The air is then burnt with fuel in the combustion chamber, and passes into the turbine. It expands down through the turbine, thus producing the power required to drive the compressor. Finally its remaining static pressure is converted into velocity in a propelling nozzle. The design of some of these components will depend to a large extent on the speed at which the aircraft is flying, while others will be little affected by a change in speed. The compressor, combustion chamber and turbine will look very much the same in an engine designed for 500 m.p.h. as for one designed for 1,500 m.p.h. The principal difference would be in the matching together of the different stages of the compressor. The intakes and propelling nozzles would, however, be very different for the two speeds. For subsonic flight, compression of the air is best achieved in a pitot type of intake, which is no more than an ordinary diffuser. At high supersonic speeds, however, such an intake would be too inefficient, because it would have a single plane shock wave across it leading to low pressure recovery. Under these conditions it is necessary to use an intake, such as the usual centre-body type, giving an oblique shock wave with high pressure recovery, followed by a nearly plane shock wave reflected from the lip of the cowling.

The optimum air flow that can be passed through intakes such as these varies with the speed of flight. If the air flow seriously departs from this optimum, not only will there be a loss of pressure recovery, but also a large increase in drag. The air flow that can be swallowed by a jet engine also varies with the speed of flight, but the requirements of the intake and the engine are, in general, not the same. To get the best performance, therefore, the swallowing capacity of one must be adjusted to suit that of the other. Since the intake consists of stationary parts it is easier to adjust its swallowing capacity, leaving that of the engine unchanged. The change required from the intake is one which will give an increase in flow area at the lower flight speeds. This can be done by opening additional vents to allow air to flow into the engine from the outside of the cowling, or by opening up the lip of the cowling to increase the throat area of the intake, or in a number of other ways. For similar reasons it is also necessary to have propelling nozzles which can be varied with the speed of flight. It is, for example, necessary to provide for an increase in the throat area when, in order to increase the thrust, fuel is being burnt in the engine's exhaust pipe, so as to compensate for the decrease in exhaust gas density. An increase in the final area of the nozzle at high flight speeds must also be provided so as to make it possible to expand efficiently through the full pressure ratio which is available under these conditions.

An alternative form of power plant for high speed flight is the ram jet. Although this has no compressor or turbine it does need a variable intake to get the best performance at all speeds, and it needs a propelling nozzle which can be varied to match the intake.

NEED FOR FLIGHT SIMULATION

The use of flying testbeds to get early flight experience on power plants will be far more restricted than in the past. It has always been difficult to obtain for this purpose fully developed aircraft which are capable of covering the full range of speed and height over which it is desired to test the engines. As the speed of flight is raised into the high supersonic range this difficulty becomes increasingly great.

Another more insidious change has been developing over the years as a result of the wider range of conditions which the engine has been required to cope with. Not so many years ago an engine had to operate from sea-level static conditions to about 350 m.p.h. and 40,000 ft. altitude. We are now looking to the time when it must fly up to 2,000 m.p.h. and, say, to 100,000 ft. The corrections that have to be made to the sea-level static performance of the engine in order to deduce its performance at full speed and maximum height will therefore be far greater than formerly. These corrections will, moreover, have to be made with little help from flying testbeds.

This wider range of operating conditions means that the power plant has to be made far more flexible in operation than has hitherto been necessary. It is for this reason that the variable intakes and exhausts, to which reference has already been made, are required. These variable features in the power plant again make it more difficult to predict flight performance from a knowledge of the performance of the components and of the complete engine under sea-level static conditions.

Probably the most important change in conditions is bound up with the interaction of the engine and its intake under non-steady conditions. In subsonic flight there are a few serious problems associated with the dynamic behaviour of the intake-engine combination, such as the consequences of a boundary-layer break-away in the intake due to disturbances caused by aircraft manoeuvres or by gun firing. In supersonic flight, however, the flow pattern in the intake is far more sensitive to disturbances, and movements of the shock-wave system may give rise to flow instabilities which have a serious reaction on the performance of the engine and hence on that of the power plant as a whole. For example, if the pilot suddenly moved his throttle position in supersonic flight, the resulting changes in the geometry of the intake, the intake shock pattern and the air flow into the engine might produce an unstable condition which would be incalculable and which would wreck the engine.

On top of all this, engines are steadily becoming

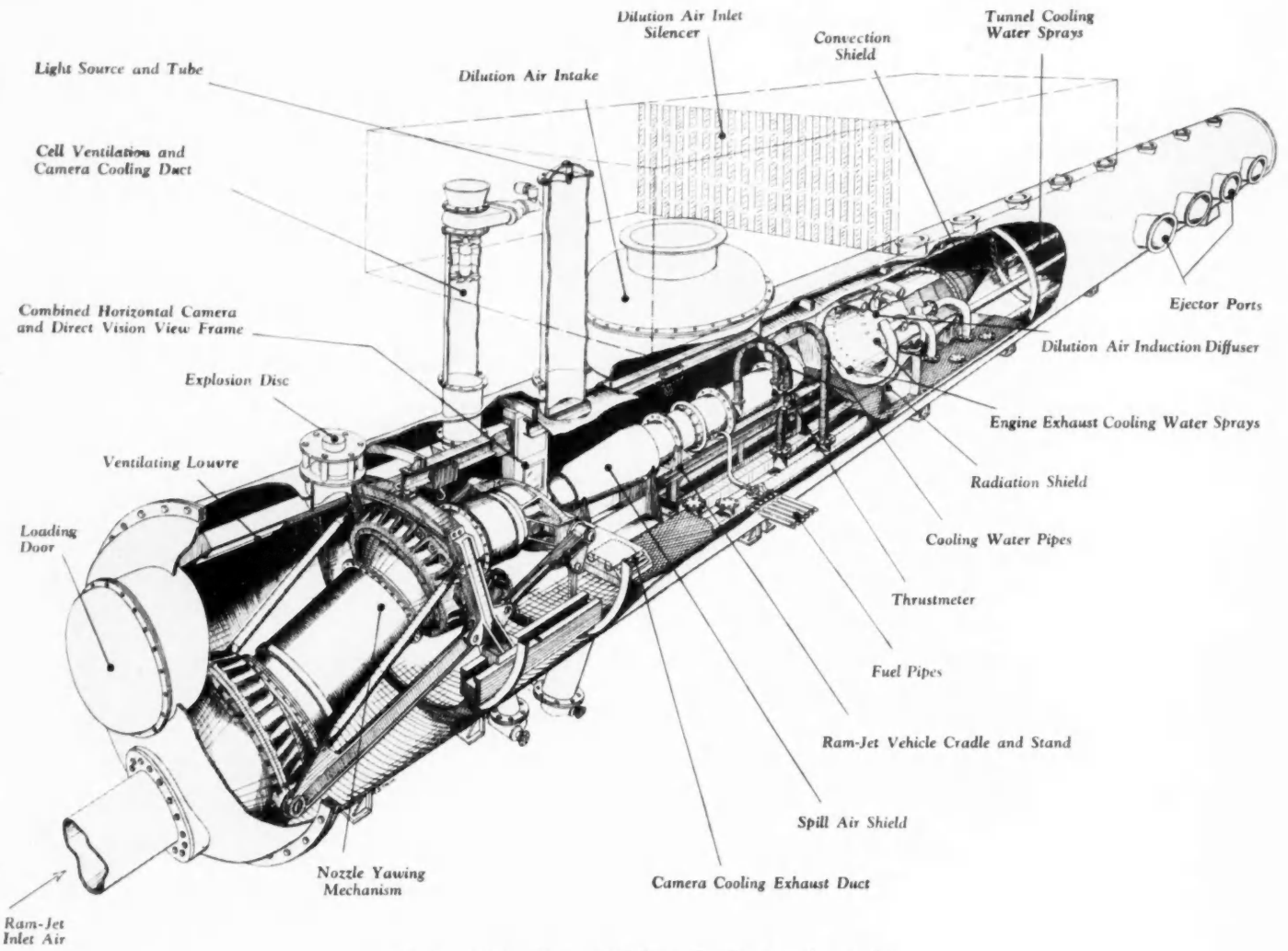


Fig. 5 A test cell arranged for a free-jet test of a ramjet.

more refined and therefore more temperamental and unpredictable. We can therefore no longer rely for our knowledge of how an engine behaves in flight on component tests under simulated flight conditions combined with sea-level tests on complete engines supplemented by a certain amount of testing in flying testbeds. It has become necessary for us to subject the power plant to conditions simulating those experienced in full flight.

OPERATING LIMITATIONS

To simulate conditions in flight completely would involve placing the power plant in its wing, nacelle or pod in an airstream at the proper pressure, temperature and velocity, the cross-section of the flow being sufficiently great to ensure that the flow past the power plant was not affected by the boundaries containing the flow. Taking the simplest case of an engine in a pod, a power plant of 4 ft. diameter to be tested up to 1,500 m.p.h. would require a jet of air over 20 ft. in diameter to ensure freedom from interference, the exact size depending very much on the conditions of test. The large diameter required in this tunnel is fixed by the need to prevent the shock wave from the nose of the engine, after reflection from the tunnel wall, from impinging on the engine pod or the unmixed wake from the pod. If such a reflection is prevented and various other conditions are satisfied, then the power plant should behave as though in free flight.

The power required to operate a wind tunnel of this kind simulating flight in the stratosphere would be some 750,000 h.p. and the cost would be over £100 million. Fortunately, however, it is possible to devise arrangements which, at a very much smaller cost, would give most of the important information that could be obtained from complete flight simulation in a tunnel.

The essential feature of these arrangements is that the whole engine should not be subjected simultaneously to the complete environment appropriate to any particular condition of flight, but that certain features of that environment should be applied in succession, and then not necessarily to the whole of the engine. This is made possible by the fact that the internal behaviour of the power plant—and this is what we in the engine world are principally concerned with—is determined almost entirely by the intake conditions and by the conditions at the throat of the propelling nozzle (assuming this to be choked).

Before we examine what effect on the validity of our measurements is likely to result from applying to the engine in successive tests, instead of simultaneoulsy, some of the various features of its environment, such as intake temperature, intake pressure, intake velocity and exhaust pressure, we should first consider how it is that such a procedure makes possible much less expensive test plant.

The condition leading to the most expensive test is that which requires that the shock-wave reflection from the flow boundary must not interfere with the mixing interface between the exhaust jet and the free stream. If this requirement is met, as in a complete wind tunnel, then complete simulation of the engine environment can be obtained, but a very large flow boundary, or tunnel diameter, is required. If we ignore the effects of tunnel interference (that is, shock-wave reflection) on the exhaust jet, then we have only to ensure that the shock wave reflection does not interfere with the intake flow. Fig. 4 shows that this can be done if the reflected shock impinges on the engine nacelle downstream of the lip of the intake. It also shows that this limitation in the position of the reflected shock can be achieved with a greatly reduced flow boundary. This results in a large reduction in the size of the plant.

As another example, let us consider the effect of intake air temperature on the engine. The temperature of the intake air affects the aerodynamic, thermodynamic and mechanical behaviour of the engine in a way which is in the main independent of the shock-wave pattern at the entry. It can be studied, therefore, by supplying the engine with air at the appropriate temperature without at the same time allowing a surplus of air to flow round the engine so as to create the correct shock-wave pattern at entry. This is known as a " connected test " as opposed to the " free jet test " in which the engine draws what air it needs from a free jet, the excess air being allowed to flow round the engine. The amount of air which has to be heated up or cooled down is therefore much less and the cost of the facility is correspondingly reduced.

Thus by subjecting the engine in succession to a number of tests in which complete simulation of the entry conditions, or of the exhaust conditions, or partial simulation of entry and exhaust conditions is effected, an arrangement of the test facility can be devised whose capital cost is only a fraction of that which would be required for achieving complete simulation.

It must not be forgotten that a penalty has to be paid for this reduction in capital cost. We cannot, for example, operate with an exhaust nozzle whose throat is unchoked, in which the velocity is less than that of sound, without the engine becoming aware of the incorrect static pressure in the exhaust system. This sets a lower

limit on the throttle curve that we cannot pass without introducing corrections, but the limitation is not likely to be an arduous one. Again, an error will be introduced if the casing of the engine is not subjected to the correct static pressure, since this pressure has an effect on the tip clearances in the compressor and turbine.

By and large, however, it seems that the price in convenience, range of operation and validity of results that we have to pay for this imperfect simulation of flight conditions is small.

ENGINE TEST FACILITY

The heart of a facility of this kind is the test cell itself. Into this test cell is led air from a compressor system. This air is conditioned to the appropriate temperature in a refrigerator or a heater, depending on the speed of flight and the altitude which it is required to simulate. If the test to be done does not require the correct flow conditions to the intake to be simulated—the shock wave system in supersonic flight—then the air flow can be ducted direct to the engine. It is then only necessary to ensure that the pressure, temperature and distribution of velocity just before the compressor is similar to what would occur in free flight with the appropriate intake fitted. This can readily be checked in a subsidiary model test. Fig. 5 shows such a test cell arranged for a free-jet test of a ramjet.

If simulation of the correct flow conditions into the intake is required then the conditioned air must be led to a nozzle from which it can be blown over the intake in a uniform stream. For speeds greater than that of sound, a convergent-divergent supersonic nozzle must be used. It will usually be desirable to collect the air spilling round the engine intake and recover its pressure energy by diffusion. Under certain conditions it is a great help to have an auxiliary compressor for controlling the static pressure in the area around the intake. This compressor would take air from the intake area and pass it into the exhaust system.

The exhaust from the cell would be arranged in a variety of ways depending on the nature of the test to be made. When the exhaust system of the engine is not itself in question the exhaust gases would normally be ducted away to a cooler in which the gases would be reduced in temperature and then passed to an exhauster system and recompressed back to atmospheric pressure. Air spilled round the engine would also have to be cooled and re-compressed in exhausters.

If correct simulation of the exhaust environment is required, then the exhaust system of the engine would have to discharge into a volume maintained at the appropriate static pressure. It would then be sucked away through a cooler and re-compressed to atmospheric pressure.

The kind of information required determines the detailed layout of each test. If we need to know how an engine stands up to icing conditions we must arrange so to condition the air approaching the engine that it simulates the kind of icing atmosphere in which we are interested. Techniques for simulating many kinds of icing conditions are now available, but it is probable that in this respect Dame Nature still has some cards up her sleeve. On occasion we shall wish to study the effect on the intake and engine of yaw and incidence when the air impinges on the engine at an angle to its axis. This necessitates making arrangements for altering the direction of the incident airflow, arrangements which, when the flow is supersonic, are often very awkward. Probably the most difficult kind of test is that needed to give transient information, about what happens, for example, when an engine is accelerating. The techniques required to measure all that happens in the two or three seconds during which an engine is accelerating under static conditions at sea level are difficult enough, but they have been developed and are available. To make the same measurements in a very unstable supersonic airstream requires far more involved techniques.

This then is the kind of facility we need to test the aeroplane engine of the future, and which is, in fact, now under construction, and on part of which the first tests have already been made.

The facility will be supplied with air from two sources. The first of these is a pair of compressors which between them absorb 18,000 h.p. and compress 120 lb. per sec. up to 6 atmospheres. The other source is a battery of eight compressor/exhausters each of which at full power needs 44,000 h.p. to drive it, and delivers 200 lb. per sec. at 9 atmospheres or 270 lb. per sec. at 3 atmospheres. These machines can be used either for feeding into the intake of the engine the high-pressure air appropriate to a high flight speed or for sucking away the engine's exhaust at the low pressures which exist at high altitudes. If all these compressors were to operate simultaneously at full load they could supply air at a sufficient rate to satisfy the breathing requirements of the whole of London.

When low temperatures are required, for simulating conditions at low forward speeds, air from the compressors will be led to a refrigerating plant. In this plant the air will be first dried, then expanded in a turbine to lower its temperature to the value required. When icing conditions are required ice or water droplets of the appropriate size will be injected into this cold air.

A model of the engine test facility at Pyestock is illustrated in Fig. 6. There will be four test cells, each of which is designed to do certain specific kinds of tests. By the use of these cells, supplied by the air-conditioning plant described above, it will be possible to subject the largest aero engine contemplated to tests on the ground, simulating flight at over 2,000 m.p.h. at very high altitudes. We shall have at last a piece of development equipment which will make it possible to reduce by many months the time required to produce a new engine; a piece of equipment which will mean that our pilots will not have to stake their lives on an engine until it has been subjected to proving tests far more thorough and comprehensive than anything that has been possible in the past.

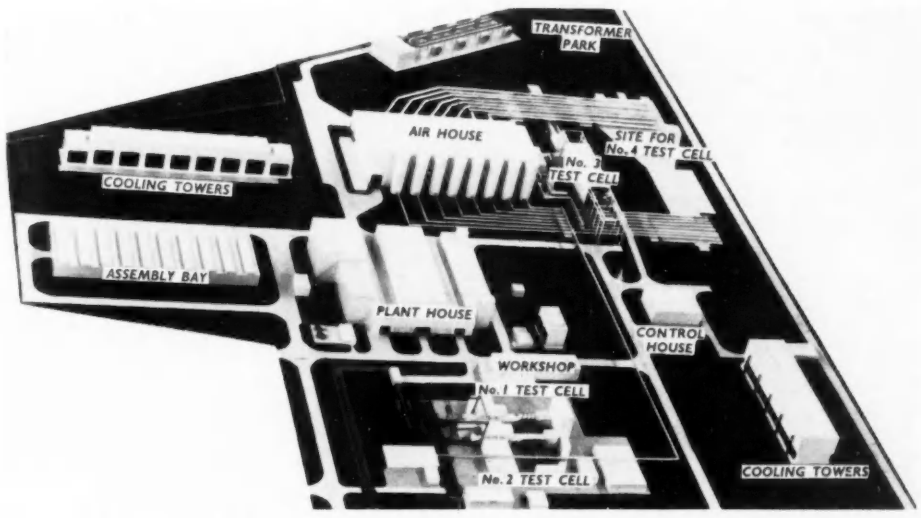


Fig. 6 Model of the engine test facility at N.G.T.E., Pyestock, now under construction. Four test cells will make it possible to test the largest aero-engine contemplated under conditions simulating flight at 2,000 m.p.h. at very high altitudes.

* * *

OSCILLATORY INSTABILITY IN FLIGHT

Current Work at N.P.L.

Among the many problems arising in the design of aircraft, one of major importance is that of guarding against oscillatory instability in flight, both of the machine as a whole and of its aerodynamic lifting and control surfaces. In estimating the behaviour of the aircraft when the balance of forces is disturbed, the designer requires a knowledge of the oscillatory aerodynamic forces arising from steady oscillations of the lifting surfaces.

Theoretical research on this is being carried out at the National Physical Laboratory, Teddington, Middlesex, which recently held two open days. Results have been provided for slowly oscillating delta wings with flaps in flows entirely subsonic or supersonic. A general theory has recently been developed for wings oscillating at any frequency in a subsonic stream; a separate investigation for control surfaces at low speeds is in progress. In all cases the computations are fairly heavy but practicable routines involving the DEUCE electronic calculator have been devised. However, theory requires a satisfactory experimental backing, and in special cases such as the transonic speed range on either side of unit Mach number ($M = 1$), where theory is inadequate, experimental evidence alone must be relied upon.

Equipment has been developed at the N.P.L. for measuring the oscillatory forces on model wings with trailing-edge flaps. The inertial reactions, large compared with the aerodynamic forces, are automatically balanced by spring reactions in a system excited at its natural frequency by an electrical feedback loop. The direct aerodynamic moments are derived from measurements of driving power and change in frequency due to the wind forces, whilst lift forces are measured by capacity pick-ups supporting the oscillatory system and incorporated in frequency modulation circuits. With this apparatus it will be possible to measure directly all the forces relating to oscillation of the flap about its hinge and to pitching oscillation of the wing about different axes. A Mach number range extending from subsonic to $M = 1{\cdot}8$ will be covered with a maximum frequency of about 100 cycles per second. Oscillatory pitching and hinge moments so far measured are in close agreement with subsonic theory.

Experiments are also being conducted on the use of jet flaps to decrease take-off and landing speeds. The 13 by 9 ft. wind tunnel is being used with a model with variable aspect ratio and jet-flap angle. The model has a body so that a tailplane can be attached to act as a downwash meter. The experiments form a fundamental study of three-dimensional effects as well as providing data for jet-flap project work.

As proposed by the National Gas Turbine Establishment, the efflux from the gas-turbine is ejected through a narrow slit in the wing, close to the trailing-edge, instead of through the usual cylindrical jet-pipe. The plane jet is inclined downwards at an angle to the flight direction, and not only provides a propulsive and lifting force by direct jet reaction, but also induces increased lift on the wing surface by generating an asymmetrical flow pattern around the wing.

A NEW INFINITELY-VARIABLE TRANSMISSION*

By W. S. Rouverol†

A mechanical power transmission based on a new principle is now under development at the University of California, Berkeley, California. It rivals the hydraulic transmission for compactness, and has a considerably higher efficiency and a wider range of output speeds. Experiments are consequently being accelerated to evaluate the effects on fuel economy, performance, and ease of operation of installing an automatically-controlled prototype in place of the hydraulic transmission in a motor car.

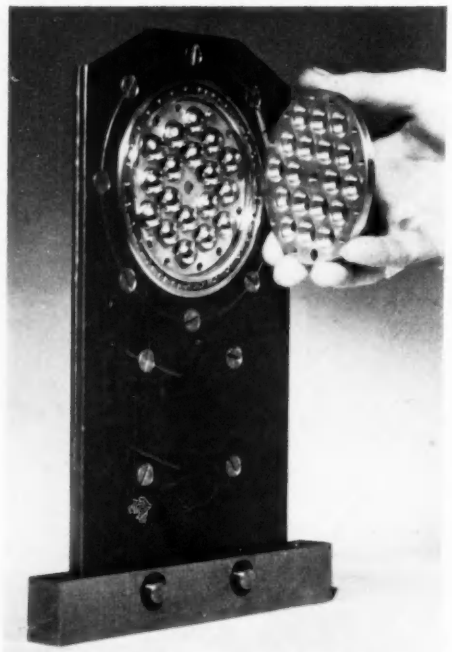


Fig. 1 Key element of a new type of variable-speed drive: a rotatable supported cage in which numerous balls are housed in spherical journal seats. When pressed between the faces of two discs at a point displaced from either axis, this element enables the balls to roll without sliding on both discs and to transmit power from one disc to the other with minimum frictional loss.

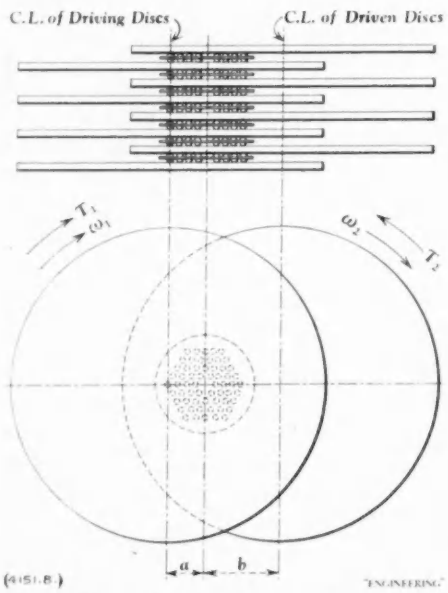


Fig. 2 Plan and elevation of the discs and cages of a multi-cage transmission. The rotatable support is not shown.

The basis of the new transmission is the observation that a sphere which rolls without sliding between two opposed rotating plates describes a circle. Translated into mechanical terms, this kinematic fact led to the construction of the element shown in Fig. 1. A cluster of ordinary ball-bearing balls are enclosed between a pair of plates of thickness slightly less than the radius of the balls. Matching hemispherical holes are provided, with sufficient clearance so that when the plates are fastened together each ball is free to rotate in place in its seat, and the entire assembly of plates and balls is mounted in such a way as to allow free rotation in the plane of the plates.

When a cage of this type is pressed between the faces of two opposed discs, with its axis of rotation lying in the plane of the disc axes, it will revolve at the average angular velocity of the discs. Each ball moves at constant speed in a circular orbit about the centre of the cage and in addition has a superimposed spinning motion about an axis which varies continuously in direction.

Despite this peculiar motion, which is even more complicated than planetary motion, each ball is able to transmit torque by means of tractive friction almost as effectively as the fixed-position ball of a ball-disc integrator. Allowing the supporting cage to revolve or "idle" enables a large number of balls to be used in a minimum of space without inducing sliding and without appreciably diminishing the torque capacity which each ball would have separately.

The axis of rotation of the cage intersects the disc faces at the point where the velocities of the discs are equal and opposite, and the ratio of the distances from this point to the axes of the driving and driven discs determines the speed ratio. Smooth variation of the output speed is achieved by lateral shifting of the cage or of one or both discs (or of coaxial groups of these elements in a multi-cage system such as shown in Fig. 2). If the discs are mounted in trunnions or slender peripheral bearings rather than on central shafts, the output speeds may be adjusted from zero to many times the input speed in either direction.

The primary power losses in a multi-cage unit are from rolling friction, and since the coefficient of resistance for steel rolling on steel is very low, the overall efficiency of the transmission is high, comparable to that of toothed gearing. Optimum efficiency is obtained by ensuring that the pressure urging the discs together to develop traction under the balls is no greater than is required for the transmission of a particular torque. Various means have been devised for relating this pressure directly to the transmitted torque.

The amount of power which can be transmitted by a particular unit depends on the maximum allowable speed. This is not clearly defined but, as in the case of ordinary ball bearings, is based on a decreasing life expectancy in inverse proportion to the cube root of the speed. The other factor on which power capacity depends, the transmitted torque, is governed by the number of balls per cage, the number of cages, the axial spacing of the discs, the safe tractive force per ball, and the uniformity of distribution of tractive forces among all the balls.

Since the coefficient of tractive friction is higher than that of sliding friction, insurance against any chain reaction of slipping requires that designs be based on the latter. In models already operated or currently being designed tractive forces have been limited to one-tenth to one-twentieth of the allowable load per ball. A number of experimental studies are now in progress, however, to determine the relative merits for this service of a wide variety of natural and synthetic lubricants with and without additives.

Distribution of the tractive load equally among all the balls depends primarily on a phenomenon called "rolling creep," whereby a rolling body measures out its circumference on momentarily stretched material, and hence advances with each full rotation a distance less than its circumference. The magnitude of this creep depends on both the normal and tractive loads. For hardened steels stressed within the elastic limit it can never amount to more than a small fraction of one per cent., but this is nevertheless sufficient to promote a fairly equal distribution of tractive load, provided that the normal load on all balls is uniform. In the automotive model now under construction, uniform normal load is achieved by applying the necessary external pressure against the outermost discs through hydrostatic thrust bearings of the same diameter as the cages and coaxial with them.

* This article is a digest of an 4,800-word paper by Professor Rouverol, from whom photo-copies of the full work may be obtained.

† Associate Professor of Engineering Design, University of California, U.S.A.

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A SHELL ANALOGY FOR FRAMED DOMES*

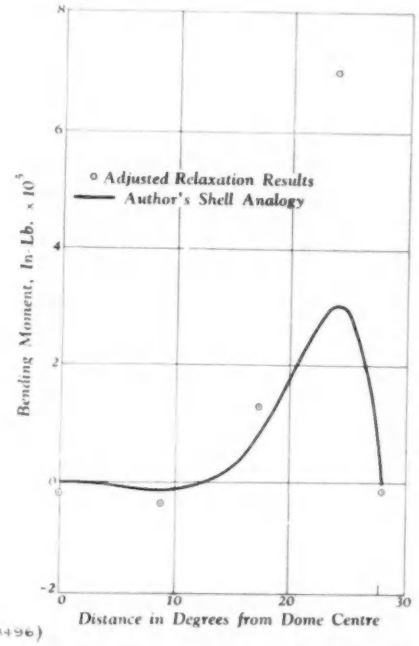
By L. H. Mitchell, B.E., PH.D.

The possibility of using a framed dome for a large radio telescope caused the author to examine the accuracy of a shell analogy, the use of which enabled an analysis of the dome to be made with considerably less labour than a relaxation solution. In the framing considered, the basic units were equilateral triangles and the arrangement was the same as that employed in the Dome of Discovery on London's South Bank. Fortunately, *The Structural Analysis of the Dome of Discovery*, by Dr. T. O. Lazarides, had been published† so that a comparison could readily be made with the relaxation results given therein.

It is shown in the Note that a frame composed of equilateral triangles is equivalent to a plate for which Poisson's ratio is 1/3 and the stiffness per unit width $E_a t$ is $\frac{2AE}{\sqrt{3}l}$, where A is the cross-sectional area, E the Young's modulus and l the length of the frame members. The bending rigidity of the equivalent plate is $D = \frac{3\sqrt{3}}{4}\frac{EI}{l}$, where I is the moment of inertia of the frame members. Using these relations and a standard shell analysis, the forces and bending moments per unit width of the equivalent shell were calculated for the Dome of Discovery for the case of a uniform load. From these results the thrusts and bending moments resisted by the frame members were estimated and the results for a main rib are compared with the relaxation solution, as shown in the accompanying graphs. The thrusts were found to be well within the limits required for design purposes. In the case of the bending moments there was a large discrepancy near the rim. The relaxation solution, unlike the analogy solution and the actual Dome conditions, assumed the loads to be concentrated at the panel points and therefore large adjustments to the bending moments had to be made before a comparison could be made at all;

* An abstract of Note SM.208 of the Aeronautical Research Laboratories, Australia. A limited number of copies are available on application to Department of Supply, Aeronautical Research Laboratories, Box 4331, G.P.O., Melbourne, Australia.

† Crosby Lockwood and Son, Limited, London, 1952.



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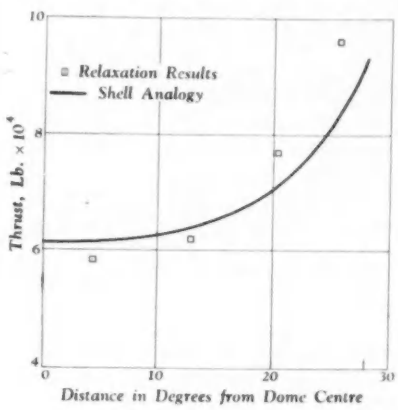

The variations in the bending moment and thrust along a rib, No. 01234, of the Dome of Discovery, have been determined by a relaxation method and using a shell analogy. The differences between the two solutions are illustrated here; they are most pronounced in the bending moment near to the rim of the dome.

also, the loading in the relaxation solution was not quite uniform and the bending moments are sensitive to small changes in the load distribution. Consequently it is possible that the quoted relaxation results are not the more accurate approximation to the moments which actually occur in the Dome. It is therefore suggested that this shell analogy method permits sufficiently accurate analyses of such domes to be made with considerably less labour than other methods.

The author wishes to thank the Chief Scientist, Department of Supply, Australia, for permission to publish this abstract.

"TOWARDS THE ALWAYS RECEDING PERIPHERY"

The Growth of Measurement Techniques

"It seems to be of the nature of the relation between the human mind and the events that make up the universe that the approach to control and understanding is a process in which success leads always to the envisaging of more problems than it solves. Speculation and tentative generalisation, as well as the search for, and the development of, new technical approaches, are the legitimate weapons to take us further towards the always receding periphery." These words of Macfarlane Barnet were used by Sir Harold Hartley in the closing passages of his paper "The Contribution of Measurement to Discovery," given to the Society of Instrument Technology. Sir Harold has recently been elected to the office of President of the Society.

He considered that one might distinguish three main spheres in which measurement has contributed to discovery. First, measurement has provided the data showing the interaction of various physical factors which have enabled scientists to find a simple mathematical formula, such as Boyle's law, to express their relationship. Second, it permitted the characterisation and identification by measurement of substances and structures, both living and dead. Third, it allowed the investigation of the mechanism of physical changes, such as the course of chemical reactions and of radioactive changes, and in a much more difficult and complex field, the investigation of the mechanism of living processes, such as metabolism, nervous action, growth and disease. Although the three fields merge into one another they give a convenient means of classification. However, this form of analysis was not pursued, and, instead, a history was given of the part played by measurement in successive ages.

The achievements of the early Greek astronomers were outlined by Sir Harold who considered them the first great masters of measurement. He then went on to discuss the work of Newton, since much of it was inspired by astronomical observations. A feature of the paper was the interest shown in the personalities of the scientists mentioned. Sir Harold remembered Lord Keynes describing Newton as "The last of the Magi . . . he looked on the whole universe and all that is in it as a riddle, as a secret which could be read by applying pure thought to certain mystic clues which God had laid about the world to allow a sort of 'philosopher's treasure hunt to the esoteric brotherhood'." Sir Harold added that Newton was a mystic, steeped in the writings of the alchemists, and in the years in which he was writing the Principia, much of his time was spent in solitary experiments following their clues.

As an instance of the new attitude of man towards his environment—that the impulse of the Renaissance had set in motion—which found expression in the experimental method, the works of Galileo and Hooke were mentioned. Of the latter Andrade says "His name is known to every student of sciences for Hooke's law, connecting elastic stress and strain, and Hooke's joint, also called the universal joint, but these form a very small part of his record. He invented many instruments, including one for measuring the moisture of the atmosphere, one for measuring the force of the wind, and a registering rain-gauge, and made very great improvements in other instruments, for example, in the microscope, the barometer and the air pump. He invented the clock-driven telescope, for following the stars, and made great advances in the use and construction of telescopes in general. He made great improvements in the construction of clocks and watches. He demonstrated that to each sound corresponds a given number of vibrations per second, and showed how to measure this."

Sir Harold went on to remark that much of the work performed by Hooke's contemporaries was observational and lacked the discipline that measurement can give and it was not unfair to say that the lack of emphasis on measurement continued during the first half of the Eighteenth Century, until the contributions of Joseph Black, Henry Cavendish, Lavoisier and Laplace. Black discovered the phenomenon of latent heat. Sir Harold stated that he had often heard it said that science owes more to the steam engine than the steam engine owes to science. He wondered if the speaker recalled that James Watt's invention of the condensing steam engine owed its inception to his friendship with Joseph Black, from whom he learned the phenomenon of latent heat.

In the period that followed, a growing emphasis on measurement developed and instrument technology became of increased importance. Several instances of ingenuity on the part of individual investigators were outlined by Sir Harold. By the end of the Nineteenth Century there was a certain feeling that the physical sciences might be nearing finality in their explanation of Nature's ways. However, there were two important discrepancies, both dependent on measurements, which needed explanation: the distribution of black-body radiation and the constancy of the velocity of light. Investigation of these problems led to reassessment of the finality of explanations.

Having commented that measurement is providing the clues but is leading to pictures of ever greater complexity, Sir Harold said that one might well ask whether the stage is set for some modern Newton.

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BAR AND ROD ROLLING MILL AT STOCKSBRIDGE

The main buildings for the new £2¼ million bar and rod rolling mill at the Stocksbridge works of Samuel Fox and Company, Limited, a subsidiary of the United Steel Companies Limited, Sheffield, are now virtually completed and foundations have been laid for a number of the rolling-mill stands. In the 850 ft. long rolling-mill bay, the foundations of Nos. 1 and 2 stands of the three-stand 18 in. roughing-mill train have been completed, together with the foundations for the four stands of the 11 in. intermediate train. In some cases, the mill bedplates have been put down and the erection of the mill stands will begin shortly. Work is proceeding on the foundations of the other mills, which include a four-stand 11-14 in. "cross-country" mill and a six-stand 10 in. continuous finishing train.

This highly mechanised mill plant is designed to roll bars and rods in alloy, high-carbon and stainless steels for the ball-bearing, motor, vehicle and tractor industries and, we are informed, will be the fastest mill of its type in the country—rolling at over 3,000 ft. per minute in the finishing train.

For heating the billets prior to rolling, the scheme includes a 25 tons per hour heating furnace and a batch furnace; the foundations for both are completed.

Adjacent to the rolling-mill bay is the 950 ft. long dispatch bay, which is being used at present for the storage of mill machinery and equipment, including mill run-out tables, many of which have been fabricated at the Stocksbridge works.

The structural steelwork for the third main bay—containing the motor room, engineers' workshops, roll turners' shop and the amenities block—has been erected and the brickwork is nearly half completed. The main mill drives have been delivered and will be installed in the next few weeks.

In the 250 ft. long heat-treatment section, which is attached to the mill within a common building plan, three of the six bar heat-treatment furnaces are nearing completion.

Ten electric overhead travelling cranes of varying capacities from 10 to 25 tons will serve the rolling-mill bays, and of these six have been installed already and are aiding the constructional work.

The main contractors for the erection of the new buildings are the United Steel Structural Company, Limited, Scunthorpe, Lincolnshire.

Book Reviews

A PYRAMID OF SCIENTISTS

The Organisation of Science in England. By D. S. L. CARDWELL. *William Heinemann, Limited, 99 Great Russell-street, London, W.C.1.* (18*s.*)

This is a well documented sociological study of the factors making for the development of science in an industrial community, based on a history of the development of scientific and technical education in this country. The repetition, several times within a hundred years, of the same pattern of panic created by comparison with other countries, of Royal Commissions, of private propaganda efforts, of traditional resistance and of Government parsimony is a depressing reminder of the wasted years which we are now desperately trying to recover.

It was the great Exhibition of 1851 which, for all its success, revealed the deficiencies in applied science from which British industry was increasingly to suffer in the future and which were even the cause of the migration of men such as John Cockerill to France. During the Nineteenth Century many attempts were made to expand the teaching of science and to provide technical education for the masses, but they all failed on the inadequacy of the school system. This was the period of the rise to domination of the examination system culminating in the external degree examination of London University which, whatever its faults, paved the way for the new provincial universities so tardily established at the beginning of this century.

The author is at pains to controvert the argument of some social historians that it was lack of economic demand which hindered the development of a body of professional scientists from the group of devoted amateurs who made the great discoveries of the Seventeenth and early Eighteenth Centuries. In his view, applied science could not develop, nor its use be appreciated by industrialists, until the development of university education and the secondary school system on which it is based had led to the emergence of a class of academic professional scientists. In Germany, for instance, the German educational revolution preceded the applied science revolution by quite a few years and in England, while the increase of academic Fellows of the Royal Society increased four times as fast as applied scientists between 1881 and 1914, this process was reversed between 1914 and 1953.

The scientific revolution that has taken place since the beginning of the century does not depend on a small group of top rank men, but on the growth of a pyramid based on large numbers of the rank and file. These developments were not possible in the individualist climate of Nineteenth Century Britain, for, if the argument of the primacy of educational provision over industrial demand is accepted, substantial state aid was required before the profession of science, and particularly of applied science, could become accepted. It was not possible for industrial requirements on their own to break down the barriers of Latin and Greek buttressed by class privilege and the Established Church. In so far as science was taught at the older universities it was part of a liberal education, and distinction in the Mathematics Tripos at Cambridge, in particular, was a coveted opening to a career in the Church or at the Bar. However necessary the development of science as a seperate vocation, may be, the loss of this tradition is one of the casualties which we suffer from its inevitable professionalisation and the growth of a demand by industry for specialists.

ACTION AT A DISTANCE

Instrument Technology. Vol. III: Telemetering and Control. By E. B. JONES. *Butterworths Scientific Publications, 4 and 5 Bell Yard, Temple Bar, London, W.C.2.* (40*s.*)

Barely 25 years ago many industrialists regarded measurement, and especially automatic control, as an extravagant and even unnecessary refinement. At that time perhaps there was some justification for this point of view—it is only within the last two decades that the fundamentals of automatic control have been established on a firm theoretical basis.

In comparison with other branches of engineering, that of instrumentation and "automation"—a word which has been adopted to describe all the activities associated with placing manufacturing processes under the control of automatic equipment—is still in its infancy. Yet such has been its impact on industry that few, if any, managements or engineers will deny that measurement and automatic control now form one of the most important links in the operations involved in the processing of raw materials and the manufacture of entirely new substances, for example, plastics, which do not exist in the natural state.

Except for a few large companies with far sighted managements prepared to invest in the future, the extremely rapid advance made in recent years in industrial measurement and automatic control has caught industry unawares. This has resulted in a chronic shortage of trained instrument engineers and there is an urgent need for expanding the facilities for further education in this and allied subjects. Therefore, the appearance of new technical publications dealing with the many facets of instrumentation is a welcome contribution to the sum total of information already available; "Instrument Technology" falls within this category. Volume III is limited to telemetering—the transmission of the values of physical quantities over a distance—and automatic control. In conjunction with volumes I and II, which deal with the measurements and analysis, virtually the whole field of industrial measurement and control is covered.

The prime purpose of this volume, as of the preceding two, is to provide a complete set of text-books for those who intend to specialise, or are interested, in this branch of engineering. Most of the requirements of the intermediate and final examinations in the instrument maintenance course of the City and Guilds College, London, are covered. However, students are not the only ones who will find this book useful. Experienced instrument engineers will find much that is instructive and of value.

The section on telemetering is divided into pneumatic and electric systems, the latter including electric circuits for the summation of values and electronic and audio-frequency transmission systems. Perhaps rather too much has been attempted in the way of describing electrical circuits, the text tending to become shorter when circuits involving the use of electronic equipment are being considered. In fact here the text is by way of a summary of the subject, it being assumed that the reader has considerable knowledge of electronic techniques. About three-quarters of the volume is devoted to automatic control. The theory of this is dealt with very fully and a successful attempt has been made to reduce mathematics to the minimum. A comprehensive description is given of a wide range of industrial controllers, covering pneumatic, electric and the latest electronic control equipment. Finally, a brief description is given of programme and other types of specialised controllers. A useful practical point is that the names are mentioned of the firms who manufacture the various items of equipment described.

For the student there is a list of questions from City and Guilds College examination papers. The questions include the subjects dealt with in volumes I and II of this series of books. A feature of the book is that the principles of operation of the various items of equipment are illustrated by simple and easily understood diagrams, which are followed by drawings and photographs of the same equipment as it appears in practice. The value of the book would be enhanced if a bibliography had been included. No reference is made to any publications or technical papers related to instrumentation which could be useful for further reading.

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NEW BOOKS

The Story of Wortley Ironworks. By C. REGINALD ANDREWS. Second edition. *R. Milward and Sons, Limited, Leen Gate, Lenton, Nottinghamshire.* (7*s.* 6*d.*)

This is the second edition, revised and enlarged, of a book which first appeared in 1950. At that time the hope was expressed by the author, the late Rev. C. R. Andrews, that means would be found to preserve at least a part of the old Wortley Ironworks, and it is pleasing to know that Mr. Andrews's sister, Dr. Mary Andrews, who has edited the revised edition of the book, was able to preside at a ceremony in 1955, when the Top Forge was officially opened as an industrial museum. The building is scheduled as an ancient monument, and a *Friends of Wortley Fund*, founded by the Sheffield Trades Historical Society, exists to finance the future upkeep of the Forge. All profits from the sale of the book go to this fund.

Wortley Ironworks are on an ancient ironworking site, and their history can be traced for at least 700 years. About two-thirds of the book are devoted to a study of the documented history of the works, some of the chapters being reprinted from the original edition, while others have been modified as a result of later research. But the history of a works rests on more than documents—it is concerned also with people, and the book does a good service in gathering together some anecdotes of former staff and workpeople, sturdy characters of a type extinct to-day, but an essential part of such a works as Wortley, even as late as in the time of the author's memory.

There is a third element, too, in the history of a works—a vital one which is all too often forgotten by historians—and that is machinery. Here again the book has, within the limits imposed by its size, brought together some useful information and illustrations. Couple with that the fact that the Top Forge, formerly used for railway axle manufacture, is now preserved, complete with its water-driven hammers and other machinery, and the work of the Andrews family and their enthusiastic helpers stands out as a valuable contribution to industrial history. It is a welcome sign of the increasing interest in the history of industry that a second edition of the book should be needed. Too often in the past we have neglected our rich heritage in this field, scrapping and failing to record. An example has been set in the case of Wortley which it is to be hoped others will follow.

Computers: Their Operation and Applications. By EDMUND C. BERKELEY and LAWRENCE WAINWRIGHT. *Reinhold Publishing Corporation, 430 Park-avenue, New York 22, N.Y., U.S.A.* (8 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (64*s.*)

A book for the non-specialist, that describes the techniques and equipment of automatic computing. The basic elements of digital, analogue and miniature computers are explained, as are considerations of reliability and maintenance. A large chapter is devoted to applications. There is a bibliography and also a glossary of computer terms. The book is written with both engineer and business executive in mind.

Process and Physical Metallurgy. By J. E. GARSIDE. Second edition revised. *Charles Griffin and Company, Limited, 42 Drury-lane, London, W.C.2.* (54*s.*)

Written to meet the needs of those studying metallurgy from the standpoint of the user of metallic materials, particularly from the engineer's angle, Dr. Garside presents the whole field of theoretical metallurgy and complementary subjects in one volume. In addition to the general revision of the existing text, two new chapters have been incorporated in the

present second edition. One of these deals with powder metallurgy and the other with the corrosion of metals and alloys.

Practical Geometry and Engineering Graphics. By W. ABBOTT. Sixth edition. *Blackie and Son, Limited*, 17 *Stanhope-street, Glasgow, C.4.* (22*s.* 6*d.*)

In the preface to this book, the author states that it is intended to provide a course in practical geometry for engineering students who have already received some instruction in elementary plane geometry, graph plotting and the use of vectors. It also covers the requirements of secondary school pupils taking practical geometry at the advanced level. Some new material has been added to the earlier editions together with a representative selection of worked examples.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Mobile Compressors. HYMATIC ENGINEERING CO. LTD., Redditch, Worcs. Air compressors mounted on hand trolleys; electric or petrol driven. Models from 7 to 60 cub. ft. per min. displacement. Minimum working pressure 100 lb. per sq. in. Leaflet.

Reflectors. CLARKE, CHAPMAN & CO. LTD., Victoria Works, Gateshead-upon-Tyne, 8. "Brytal" aluminium and silvered glass reflectors—parabolic, spherical, elliptical. Standard sizes range from 1 in. to 79 in. in diameter. Publication No. 114B.

Voith-Schneider Propellers. E. C. GOLDSWORTHY, Estate Buildings, South-road, Weybridge, Surrey. Examples of ferry boats using the Voith-Schneider propeller, together with a description of the unit are given in an illustrated leaflet.

Jointing, Packing, and Insulation. BELDAM ASBESTOS CO. LTD., Lascar House, Hounslow, Middlesex. Catalogue of jointing, packing and insulating material for most applications. Also tools sealing compounds and strainers.

Fire Protection. FIRE PROTECTION ASSOCIATION, 15 Queen-street, London, E.C.4. Common causes of electrical fires are set out in a leaflet "Electricity —and Fire."

Slotted Angle. DEXION LIMITED, 65 Maygrove-road, London, N.W.6. Uses and applications of Dexion slotted angle are described in quarterly bulletin and film.

Mobile Crane. B. G. PLANT (SALES AGENCY), LTD., Pyrton Hill House, Watlington, Oxfordshire. "Hydrocon" lorry mounted cranes, 3 ton and 6 ton models. Leaflet.

Chemicals and Plastics. MONSANTO CHEMICALS LTD., Monsanto House, 10-18 Victoria-street, London, S.W.1. Illustrated brochure listing the company's products and giving some of their applications.

Diesel Engine Servicing. CUMMINS ENGINE CO., INC., Columbus, Indiana, U.S.A. Bulletin designed as a wall chart to cover the most frequent troubles encountered in engine operation.

Light Fittings. A.E.I. LAMP AND LIGHTING CO. LTD., Crown House, Aldwych, London, W.C.2. The "Satina" range of pendent lighting fittings with opal glass shades. Leaflet.

DIESEL-HYDRAULIC LOCOMOTIVE

TORQUE CONVERTER TRANSMISSION

The Diesel-hydraulic locomotive is now well established, and several types are in operation using torque converters of various designs. A new type, designed for simplicity, has been introduced by Andrew Barclay, Sons and Company, Limited, Kilmarnock. This locomotive is fitted with a Twin Disc torque converter, believed to be the first application to a locomotive in this country.

The locomotive is of the 0-4-0 type and is fitted with a National five-cylinder Diesel engine developing a maximum of 200 b.h.p. at 1,500 r.p.m. It is intended for shunting duties, for which class of work the most desirable characteristic is a high tractive effort for starting combined with a steady pull to minimise wheel slip.

The Twin Disc three-stage torque converter used is capable of giving a maximum range of 5 or 6 to 1, and can therefore be used as a single unit in a shunting locomotive, avoiding the use of a combination of torque converters and fluid couplings. The operation is entirely automatic, depending on the speeds of the input and output shafts. In practice the full range of 5 or 6 to 1 torque multiplication is not used as the efficiency is low when the multiplication is high but a torque multiplication of approximately 4 to 1 can be used, which is equivalent to that obtainable from a normal four-speed gearbox. Under these conditions the efficiency of the converter is 70 per cent. at each end of the range, and at the optimum speed the efficiency rises to a maximum of 82 per cent. The graph in Fig. 2 shows the performance of the converter on an output r.p.m. base, while Fig. 3 shows the corresponding tractive effort of the locomotive on a speed base.

The smooth variation is of particular importance when working with loose-coupled rolling stock. Compared with a two or three-stage hydraulic transmission, there is no governor or arrangement of valves to control the change-over from one stage to the other, nor is there any free wheel.

The maximum tractive effort of this locomotive is 20,000 lb. At 2·4 m.p.h. it is 18,000 lb. and 4,500 lb. at 9·6 m.p.h., this being the range of speed in which the efficiency of the converter is 70 per cent. or over. The weight of the locomotive is 31 tons giving an adhesion ratio of 3·5 to 1 with the 20,000 lb. tractive effort. Maximum speed is 11 m.p.h. The engine is of the National M4AA5 type having five cylinders 6 in. bore by 8½ in. stroke. It is set to develop a maximum of 200 b.h.p. at 1,500 r.p.m. this being a 12-hour rating. Starting is by electric motor engaging with a toothed ring on the flywheel.

The Twin Disc torque converter is rigidly mounted on the engine crankcase, in addition to which it is supported at the output end from one of the locomotive frame stays. From the output shaft of the torque converter the drive is taken by a propeller shaft with Layrub flexible couplings at each end to a Wiseman reverse and final reduction gearbox which embodies a jackshaft.

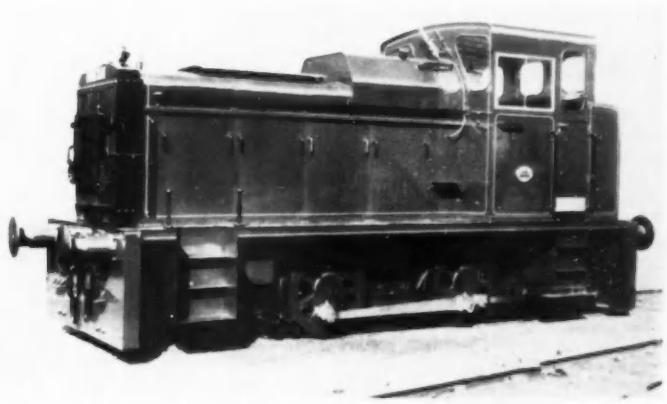


Fig. 1 A tractive effort of 20,000 lb. is developed at 2 m.p.h. by this Barclay locomotive which uses a Twin Disc torque converter.

This jackshaft is fitted with balance cranks at each end and the drive is taken from these to the rail wheels by means of connecting and coupling rods. The reverse gear is of the bevel type consisting of a bevel pinion running between two crown wheels which are mounted on roller bearings on a cross shaft. It is possible to dismantle the gearbox and remove all shafts including the jackshaft without disconnecting the principal casting from the frames of the locomotive.

A friction clutch is embodied in the torque-converter casing between the engine and the torque converter to provide a free engine when the locomotive is standing and to facilitate operation of the reverse gear. It must be engaged to connect the engine to the torque converter and must be disengaged momentarily to eliminate the drag torque of the converter to allow the reverse gear clutch to be moved. An

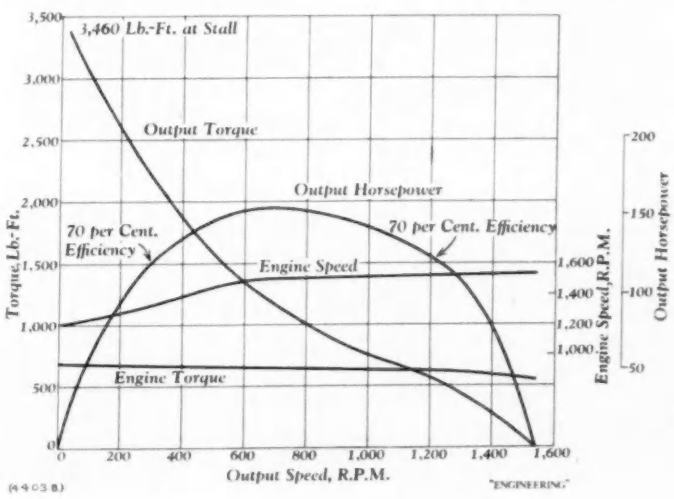
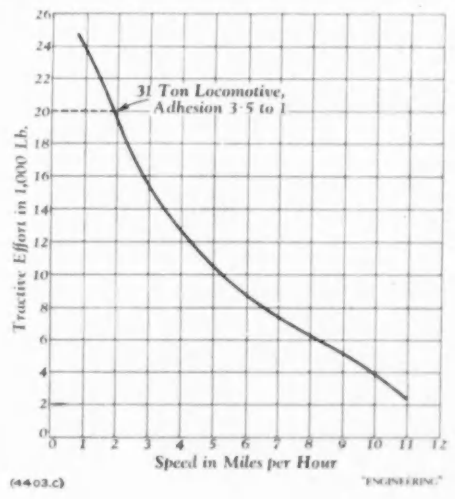


Fig. 2 (left) A transmission efficiency of 70 per cent. is maintained over a speed range of 4:1.

Fig. 3 (right) One advantage of a converter is that there are no breaks or steps in the tractive effort curve.



interlock is provided to prevent the reverse gear handle being moved unless the locomotive is stationary. This is operated by the flow of oil circulating in the final drive gearbox.

The locomotive was built for 4 ft. 8½ in. gauge with a wheelbase of 6 ft. The wheels are 3 ft. 2 in. in diameter. A fuel tank of 275 gallons capacity is fitted at the top of the casing, close to the cab so that it does not obstruct the driver's view. This fuel supply should be sufficient for about four weeks of day shift work.

The driving controls, consisting of throttle lever, clutch, brake lever and sanding levers, are duplicated so that they can be operated from either side of the cab. The throttle, brake and reversing handle are conveniently grouped on a desk in front of the driver. The brakes are of the Westinghouse compressed air type.

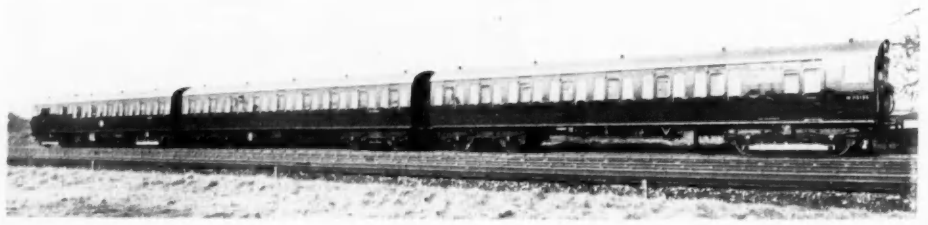


Fig. 1 A three-car multiple-unit train, now running on the Euston-Watford line of British Railways.

NEW ELECTRIC TRAINS FOR LONDON

The existing multiple unit sets used on the electrified lines of the London Midland Region of British Railways between Euston and Watford and Broad Street and Richmond are gradually being replaced by 57 three-coach units, the first of which was taken into service on May 27. Each of these units comprises a motor coach, trailer and driving trailer with seating accommodation for 256 passengers, and is arranged for multiple unit operation in sets of two or three. They were built at the British Railways works at Eastleigh and Ashford, the electrical equipment being supplied by the General Electric Company, Limited, Kingsway, London, W.C.2. An illustration of a three-coach train appears in Fig. 1.

The underframes of the coaches are of the British Railways standard all-welded type with deep main longitudinal centre guides and cantilever transomes to the 7 in. by 3½ in. channel sole bars, a design which permits easy access to the electrical equipment. Both motor and trailer bogies are also generally of standard design with a single centre bolster suspended from inside the frame. The motor coaches are fitted with two bogies with a motor on each axle. The noses of these four motors rest on a rubber block which is carried on a bracket welded to the transom. The suspension bolts, which secure the noses to these brackets, pass through the mountings and contain the rubber springs which cushion the upward thrust. The lateral thrust is also rubber cushioned. The bolster suspension is by means of a non-adjustable swing rod from the bolster transom. Both top and bottom spherical seatings are of phosphor bronze, while the coil springs are of rectangular section.

The construction of the bodies and roof framings is similar to that used in main line steam coaches so that it has been possible to employ many standard components. A number of standard fittings are also used in the interiors.

Power is supplied to the trains on the third and fourth rail direct-current system at a nominal pressure of 630 volts. Positive and negative shoe gear is provided on both bogies of the motor coach and on the bogie at the cab end of the driving trailer. All this gear is interconnected.

Fig. 2 shows a new design of positive shoe gear which is to be fitted on seven of the motor coaches. It has been developed to improve current collection, reduce wear and eliminate the noise emitted by the normal gravity types of equipment when they are not in contact with the conductor rail. A feature of its design is that rubber is used both for damping the noise and as a springing medium. Andre-Neidhart units are employed at the joints of the links, which are arranged to rest on rubber cushions when in the released position. No fuses are provided, their place being taken by an isolating switch.

The bus lines to which the shoes are connected, supply both the traction and auxiliary motors as well as the heaters in the coaches. The connections between the coaches are made by jumpers and plugs and sockets of new design in which line contact is obtained by the use of spring-loaded fingers.

Each unit is equipped with four self-ventilated traction motors the aggregate continuous ratings being 540 h.p. with full field, and 600 h.p. with weak field. The corresponding one-hour ratings are 680 h.p. and 740 h.p. The two motors on each motor-coach bogie are connected permanently in parallel, and all are fed through a double-pole isolator. Either pair can be cut out by a hand-operated switch.

Control is effected from a master controller in the driver's cab, the first notch of which provides for shunting movements, the motor groups being in series and all the resistance in circuit. Automatic acceleration to full series connection takes place on the second notch, and bridge transition and automatic acceleration to full parallel on the third. The flow of current on this last notch is controlled by a limit relay, the resistance sections in each group being short-circuited in pairs. To improve the balance of the bridge, one section of resistance, which is in circuit on the first notch, is not re-inserted at the transition stage. Further increase is obtained by moving the controller to the weak field position where a portion of each field is first shunted by a resistance under the control of a relay, the fields as a whole being finally weakened by tapping.

When the switch, mentioned above, is used to isolate either pair of motors the control circuit is modified so that all the remaining motors accelerate to parallel and the weak field position is inoperative on the unit with the isolated motors. Normal notching of both groups of resistances is retained on the affected unit.

The reverser handle has two normal forward positions which give rates of acceleration of 0·92 m.p.h. per second and 1·25 m.p.h. per second, the latter being obtained by energising the shunt coil of the current limit relay through a resistance. In addition a third rate is available for emergency use when it is necessary to start a train, on which a pair of motors has been cut out, on the 1 in 35 gradient in the Primrose Hill flyunder. This arrangement is obtained by short-circuiting part of the resistance in series with the shunt coil of the current limit ring relay.

The Westinghouse electro-pneumatic brakes are operated from a compresser on each unit which also supplies air to the electro-pneumatic control gear, the wind-screen wipers and the whistles.

In fifteen of the units described above the driving trailers will be fitted with a reservoir from which de-icing fluid can be supplied to the conductor rail via the shoegear. This supply will be controlled by electromagnetic valves, which can be operated by push buttons from the driving positions when the reverser is in either of its "forward" positions. The circuit to these valves is opened by a relay when the brakes are applied and it is also broken by contacts operated by linkage when the shoe is not touching the conductor rail.

A supply for heating is drawn from the power bus lines in each car, the heaters being connected in groups of two in series and being selected by push buttons in any van compartment; in addition they are thermostatically controlled.

Fig. 2 (right) A new design of positive shoe gear and shoe isolating switch has been used to improve collection and reduce noise.

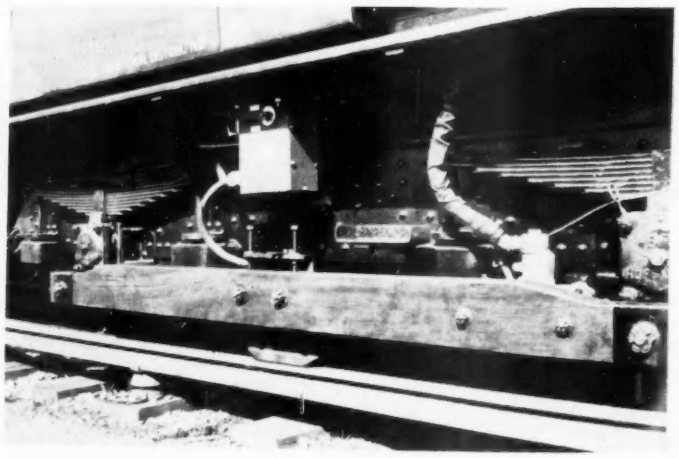
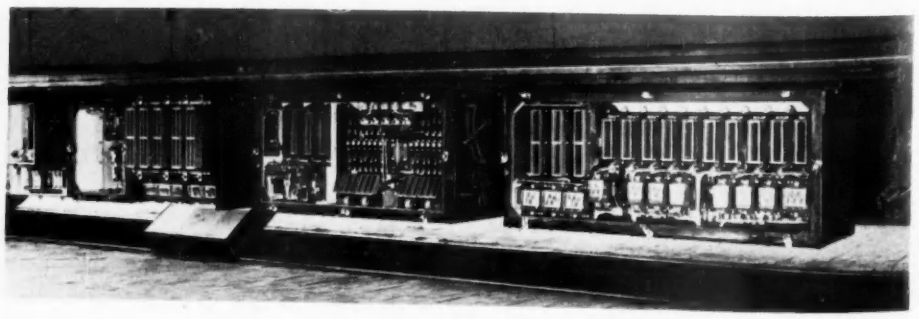


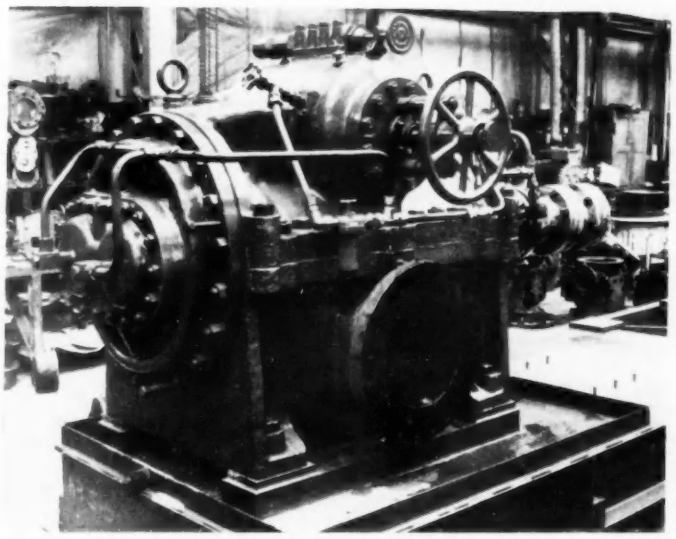
Fig. 3 (below) The three underframe equipment cases on the motor coach.



BUNKER OIL PUMP

Stothert and Pitt, Limited, Bath, recently completed the largest size they have yet made of their screw-type pump. The pumps are intended for use with heavy bunker oil in the Kuwait area, where they will boost the feed from the storage station to the ship. On test, a pump delivered 1,985 gallons per minute of oil which has a viscosity rating of 270 centistokes at 120 deg. F., against a pressure of 200 lb. per sq. in. (550 tons per hour of 1,500 seconds oil). For this, approximately 420 h.p. was absorbed. The Kuwait units are fitted with small-pitch screws and are driven, through a Metastream coupling, by a Metropolitan-Vickers 450 h.p. 33 kV 12 pole motor at a speed of 585 r.p.m. When fitted with the big-pitch screw, the delivery figures are increased by approximately 25 per cent. for the same pump speed. It should be explained that this type of pump consists of two pairs of intermeshing square threads mounted on two shafts, so that the flow of oil is from both ends to the middle. Intermeshing timing gears on one end of each shaft maintain the threads in constant relation to each other, and, in fact, there is always clearance between them. The casting of some special two-metal threads of this type was described in ENGINEERING for May 10 last, page 594.

One of the features of these pumps is that the suction and delivery branches are directly opposite each other, so that the pump can be installed in the line of the pipe, and also both branches are in the lower half of the casing. This latter feature enables the upper half to be removed to carry out any servicing required without any disturbance of the main pipework. The delivery pressure is maintained by a servo system consisting of an adjustable pilot valve and a main delivery valve which can be controlled either from the pilot valve or by a hand-wheel. There is also a hand-wheel on the pilot valve for emergency operation and starting. The operating pressure of the pilot valve can be adjusted by a spring-loaded hand control mounted at one end, and the movement of the piston then governs the flow of oil to the main delivery valve. This is also spring loaded, and by allowing oil to drain back to the suction side when the delivery pressure increases beyond the set value maintains a constant output pressure.



Intended for use with bunker oil, these screw type pumps can deliver 550 tons per hour of 1,500 secs. oil against a pressure of 200 lb. per sq. in. The branch pipes are 14 in. in diameter.

The roller bearings for the screw shaft are inboard and are lubricated by the pump oil itself. A bleed is taken off the pressure side of the pump and fed through a filter to a distributing gallery which connects with all four bearings and also with the jet that feeds the timing gears. This last ensures that there is an actual circulation of oil around the gears, and avoids merely churning up one small section of oil. One of the peculiarities of this type of pump is that the efficiency increases with the size, since the actual clearances between the screws and between the screws and the casing remain constant, but the relative clearances decrease. Moreover, with the larger sizes more accurate setting of the screws in relation to the cases is possible. These models are approximately 7 ft. 2 in. long, overall, and 4 ft. 7 in. wide. They are fitted with 350 mm. diameter screws. The pipes are 14 in. in diameter and can accommodate the higher flow produced when the large-pitch screws are incorporated. The pumps are capable of handling bunker oil up to 6,000 secs. viscosity, and can work with suction heads of as much as 20 in. of mercury.

WORKS EXPANSION ON A RESTRICTED SITE

The Phosphor Bronze Company, Limited, Bradford-street, Birmingham, 5, a Birfield Group Company, as their name indicates, manufacture a range of products of the copper-based alloy type, but, however, other materials such as white metals, nickel alloys, stainless steels, and spheroidal graphite iron are also cast.

Additional facilities for both production and administration purposes had been needed for some time, and a programme of extensions has now been largely completed. Space for expansion was limited, as the factory is near to the centre of Birmingham, and the offices have been accommodated in a multi-storey block over the street frontage of the main foundry. Certain departments, such as the pattern shop and the light shell-mould production section, are also on upper floors, but all the heavy moulding, melting and dressing equipment is on the ground floor, together with the machine shop. To facilitate internal transport, most of which is by fork-lift trucks, walls and other obstructions were removed from existing buildings wherever possible, and in the extensions, roof and crane supports have been limited for the same reason. The whole of the ground floor has been brought to a single level, and sand floors in the foundry have been replaced by concrete.

Part of the space for the extensions was provided by taking in and demolishing old property separated from the original works by the River Rea. Heavy built-up bridge girders, 65 ft. long, laid across the brick-lined channel in which the river runs, enabled the extensions to form a single unit with the other buildings, on the same floor level.

The main production floor now houses a steel foundry, with induction melting furnaces, which can also be used for other alloys and S.G. iron; a main non-ferrous foundry with hand and machine moulding equipment and oil-fired furnaces; an ingot shop, also equipped with oil-fired furnaces; a centrifugal casting foundry and a bronze stick-casting shop. Castings from a few ounces to several tons in weight are in normal production, moulds being made in green sand and dry sand, by shell moulding, by the Shaw process and by the CO_2 process. Normal production includes castings to customers' orders and the company's range of branded alloy ingots for casting purposes, and solid and cored alloy sticks. All castings can be supplied as cast, rough-machined, or finish-machined, as required.

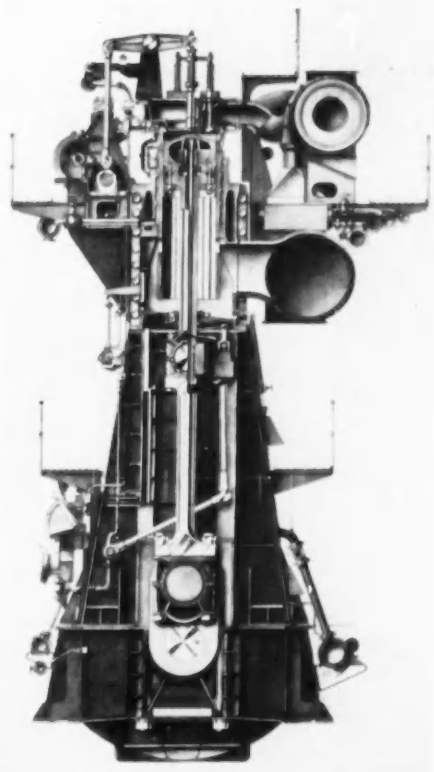
★ ★ ★

GLASGOW TO BUILD STORK MARINE DIESELS

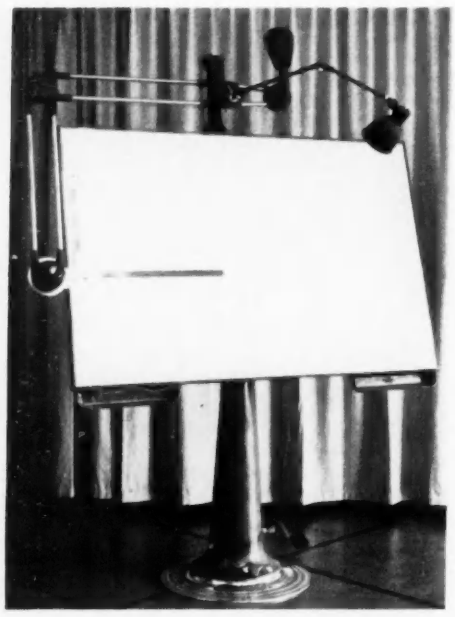
As a result of an agreement between Gebr. Stork and Co. N.V., Hengelo, Holland, and the Fairfield Shipbuilding and Engineering Company Limited, Stork single-acting two-stroke turbocharged marine-propulsion Diesel engines are to be made under licence in Glasgow. These engines cover a power output range from about 2,500 b.h.p. to 15,000 b.h.p. and, in the larger sizes, have a fuel consumption of 0·33 lb. per b.h.p.-hour on Diesel fuel.

In the Stork engines, the " uniflow " scavenging system is adopted, through ports in the cylinder liner and four mechanically-operated exhaust valves in each cylinder cover. One turbocharger is provided per two adjacent cylinders, arranged as close as possible to the cylinder heads to derive the maximum effort from the exhaust gases. The individual turbocharger units are small and their inertia is low, so there is no delay in reaching running speed as soon as the engine has fired. A separate scavenging air pump is not required.

The first ship to be fitted with a Stork turbocharged single-acting Diesel engine with uniflow scavenging was the United Netherlands Steamship Company's 10,340 ton vessel " Ouwerkerk," ordered in 1952. To-day, Stork have contracts for 99 engines and have delivered 30.



Section through a Stork turbocharged marine Diesel engine.



A ROTARY DRAWING BOARD

A drawing board stand should provide the maximum means to maintain drawing office output and at the same time occupy the minimum of floor space. A claim that these requirements have been fulfilled is made by M.B.C. (Office Systems) Limited, 31 Crouch-street, Colchester, Essex, with the introduction of the "Nike President" hydraulic drafting machine. The stand is mounted on a single pillar which allows the board to be rotated through 360 deg., thus allowing the draughtsman to take maximum advantage of lighting conditions. The angle of the board, which is balanced, is finger tip controlled by a conveniently placed knob, and a pedal on the base of the stand enables the height to be altered whilst maintaining the same angle.

TURRET JAW VICE

Several developments have taken place in the Wilson turret jaw vice since it was first introduced by W. H. Colt (Engineers), Limited, 219 Grand Buildings, Trafalgar-square, London, W.C.2, some years ago. The vice has the great advantage that it can handle irregular work just as easily as standard square sections. In the more recent models, the turret head is located in the parallel jaw position by a trigger release instead of a pin, and the lead screw is covered with a volute spring guard. Another feature is that the turret jaw is so placed that the work is clear of the bench, and can project downwards freely towards the floor. The horizontal groove in the parallel face of the turret jaw permits long work to be mounted with considerable overhang, and yet be held rigidly by the vice.

Four models are made, with openings of 2 in., 3 in., 4½ in. and 6 in. In each case, there are five shapes on the turret head as well as the parallel face, and the nominal capacity for round material is from ¾ in. diameter to 2½ in. diameter according to the model. All but the smallest size are fitted with a quick-release trigger on the screw.

Both bench and machine types are manufactured, and the machine type is readily adaptable to hold, or indeed to become, a jig or fixture. The underside is machined parallel to the upper face, and on it are placed two locating tenons, which may be set either parallel or at right angles to the lead screw, and engage in the normal slots on a machine bed. These tenons are made reversible, to fit either $\frac{3}{16}$ or $\frac{11}{16}$ in. slots in the two smaller models, and $\frac{11}{16}$ or $\frac{13}{16}$ in. slots in the larger two.

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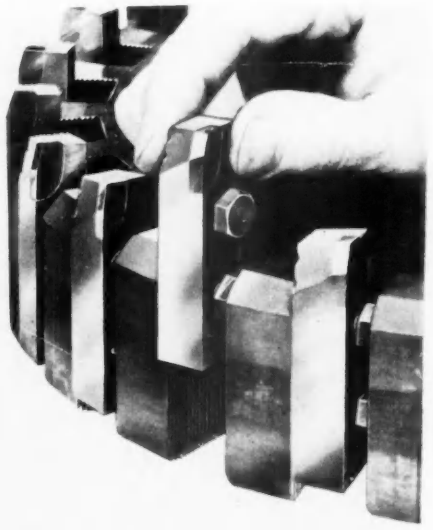
SIMPLE MILLING CUTTER

The "Abul" milling cutter, made by Harry Milnes, Limited, Montrose Works, Harwood-street, Sheffield, 2, is a new approach to cutter design. Basically of the inserted-tooth type, it takes tipped inserts which can be of a type and grade suitable for light alloys, cast iron or steel. The general construction of the cutter can be seen from the illustration, which shows a tool being inserted. It will be seen that the tools are located radially by means of serrations, and locked in the slots by set pins.

The cutter can be set with the tools in line or in progression according to requirements. Re-grinding of the tools is simplified by fixtures available from the cutter manufacturers. These fixtures, which are suitable for any standard free-hand lapping machine, ensure that all the tools are identical after lapping.



The "Abul" milling cutter has inserted tool holders carrying tips to suit the metal being machined, and can be set with the tools either in line or progressive.

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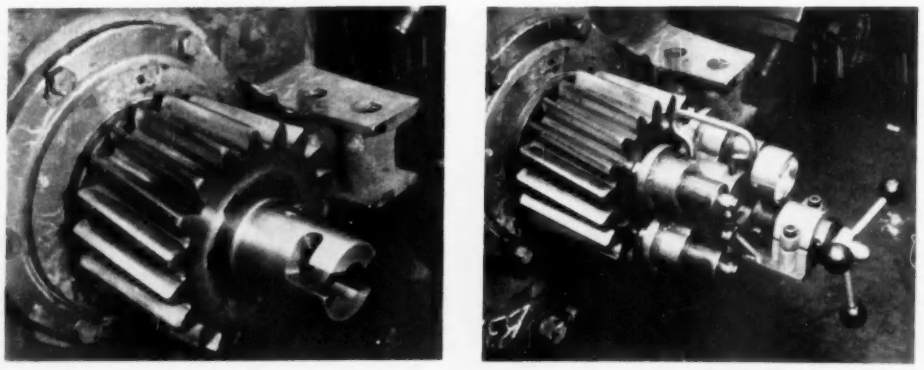
PORTABLE PINION PRESS

It has long been thought that the practice of driving pinions on to the shafts of traction motors by using a lead or copper hammer was liable to cause damage to the armature roller bearings. It was to avoid this risk of damage that London Transport developed a portable hydraulic press which would be adaptable for different sizes of shaft and for correspondingly different sizes of pinion. After an adaptor with a bayonet fitting at the end has been screwed on to the shaft the pinion is put on by hand and the press assembly engaged with the bayonet fitting.

The assembly consists of a plate carrying the adaptor socket and four bosses arranged radially at equal intervals. Within these bosses are hydraulic plungers with anvils which engage with the face of the pinion. A bracket attached to the back of the adaptor socket carries a hand-pump capable of producing a pressure of 2,500 lb. per sq. in. This gives a maximum thrust on the pinion of 2·7 tons (a pressure gauge is fitted on the pump). The adaptor has a short shaft drilled for a tommy bar, so that it can be tightened on the armature shaft. The pinion is normally offered up to the shaft in a heated condition, and the pressure applied while it is still hot. After it has cooled down, the pressure is released, and the press and adaptor removed. The hydraulic units, including the pump, are manufactured by Power Jacks, Limited, Valetta-road, Acton, London, W.3.



The hydraulic press (right) designed for fitting pinions on to armature shafts, engages with an adaptor (left) that is first screwed on to the shaft.

FILM PROJECTOR WITH NON-INTERMITTENT MOTION

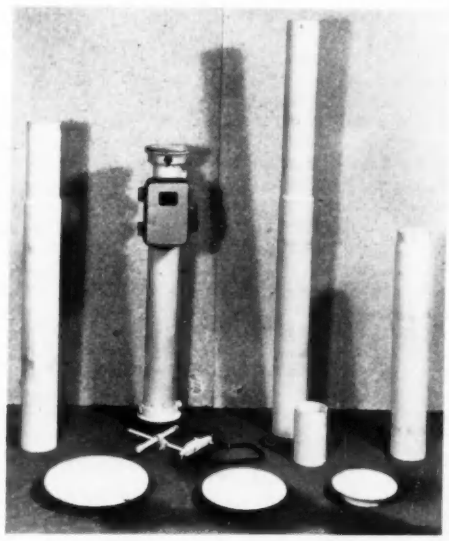
Film Accelerations Eliminated

Televising a film raises problems foreign to the field of conventional film projection. The chief difficulty is that the television camera needs to move to successive frames of the reel of film in periods of the order of one millisecond. Since the film is held stationary during the time that it is scanned by the television camera the short interval that remains for movement calls for accelerations that are high enough to pose formidable film-handling problems.

A way out of the difficulty is to use a non-intermittent film projector. Although a considerable amount of work has been done on continuous film systems, developments have only introduced equipment with no advantages over the established intermittent projector, but recently a new non-intermittent projector was the subject of a paper presented at the annual meeting of the American Society of Mechanical Engineers, in New York. The authors, Mr. O. Wittel and Mr. D. G. Haefele, described how two rotating and tilting mirrors were employed to compensate for the continuous movement of the film. Each mirror compensates the movement of alternate frames and both are semi-circular in shape. The mirrors are mounted on a drift shaft, so that they form a complete circle, and have plano-reflecting surfaces that are flat to within one wavelength of light. A camshaft and rocker arm provide the necessary control of motion. The system was designed to produce a horizontal and vertical variation of frame-to-frame image position of less than 0·0005 in.

DYNAMOMETER FOR MINE ROOF LOADINGS

A dynamometer for recording roof loadings, and measuring floor penetration and roof convergence in coal mines has been developed by the Dowty Group Limited, Cheltenham. It is basically a hydraulic prop incorporating an automatic recorder which takes a continuous reading of roof loadings on a time-based chart. A scale, pointer and sighting tube form part of the equipment and provide for easy and accurate measurement of convergence and penetration, while the chart provides a complete record of roof loadings during the test period. The unit is quickly and easily set to a yield load of 20 tons by operating a built-in hand pump, and is released by a pull on a hinged D-link under the top cap.



The standard Dowty roof-load dynamometer kit includes the basic unit—a hydraulic prop incorporating an automatic recorder—extension pieces, distance piece for additional adjustment, and sighting tube and scale for measuring floor penetration.

Roof convergence is measured on a flat scale clipped to the upper member. The scale is graduated in inches sub-divided into tenths, and is read by means of a pointer clipped to the lower member. Once set up on the face, the dynamometer requires no further attention. Convergence readings can be taken at any time, and roof loadings ascertained from the recorder chart, which provides a permanent record for future reference and comparison.

To measure floor penetration, the scale is repositioned on the lower member, and the sighting tube is secured to an adjacent prop by means of its adjustable chain clamp. Comparative readings are readily obtained and roof loadings are again plotted by the recorder.

Each chart is calibrated for a 24-hour period, and its waxed surface eliminates the need for ink: a metal stylus scribes a fine line on the chart by removing the wax to expose the red undersurface. The recorder case incorporates a spring-loaded catch, secured by a lock to prevent tampering by unauthorised persons.

If required, the dynamometer can be supplied with a simple gauge fitted in place of the automatic recorder unit. Roof loads in tons are directly indicated by the gauge, which is protected by an open-fronted steel box welded to the top member.

The dynamometers are available in two basic sizes, each complete with extension pieces to suit the various seam thicknesses that are met. A distance piece which may be slipped inside any extension tube provides extra adjustment. Both the upper and lower end caps are easily detachable, and caps of 5½, 7, 9 and 11 in. diameter are included in the standard kit to cater for differing floor conditions. A pronged cap is available as an optional extra, as well as five penetration pieces of diameters between 1 in. and 5 in.

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IRRADIATION OF DIELECTRICS

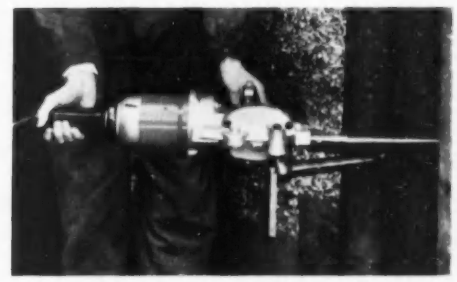
The properties of materials can be affected very considerably by subjecting them to high energy radiation. One research project now in progress at the Hinxton Hall Research Laboratories of Tube Investments Limited, is an investigation on behalf of Mersey Cables Limited, into the effects of high-energy radiation on dielectric materials. The radiation source is a 2 million volt Van der Graff accelerator.

Polythene that has been irradiated does not melt at 115 deg. C. as does its normal isomer, but is an elastic rubber-like substance which retains its form and appreciable strength. This change in properties allows soldering to be carried out close to the insulation without damage, and means that momentary electrical overloads can be tolerated which might deform or destroy the simple material.

The manufacture by Mersey Cables Limited of irradiated Polythene dielectric has now been commenced under the name of Merad. The irradiated product is free from stress cracking in the presence of detergents, and its resistance to the action of aromatic and aliphatic hydrocarbons is increased. Tensile strength, elongation and abrasion resistance are improved, while the handling and flexibility are virtually unchanged. Extruded sleeving with an inside diameter of ¼ in. when irradiated can be easily distorted to an inside diameter of ⅛ in. or more to fit over terminals or components. Upon momentary heating between 135 and 150 deg. C., it attempts to return to its original ¼ in. inside diameter, and thus encapsulates the component.

PORTABLE SAW

For the quick cutting of pipes or metal sections on site, a portable hacksaw machine is now being marketed in this country by Trend Industrial Equipment Limited, 5 The Ridgeway, Stanmore, Middlesex. It is manufactured by the German firm of Fein. The blade projects from the head of the machine and is made to reciprocate either by an electric motor or by an air motor. The blade stroke is 2½ in. Clamps have been designed to suit all sections likely to be cut and each clamp has a projecting arm and pivot that locates in a socket on the head of the machine. Pressure on the handle of the machine by the operator uses this pivot as a fulcrum to bring the blade into contact with the work and to apply as much force as is necessary. The angle of the fulcrum can be adjusted so that mitre cuts can be made if required. The blade reciprocates at 240 strokes per minute, and the cutting capacity of the machine is for 6 in. diameter steel or cast iron pipe or bar, or for profiles not more than 10 in. wide. A 2½ in. steel pipe can be cut in 1½ min. Weighing only 14 lb. for the air-operated model, or 17 lb. for the electric model, the chief claims of this machine are its portability, speed of cutting and cleanliness of cut.

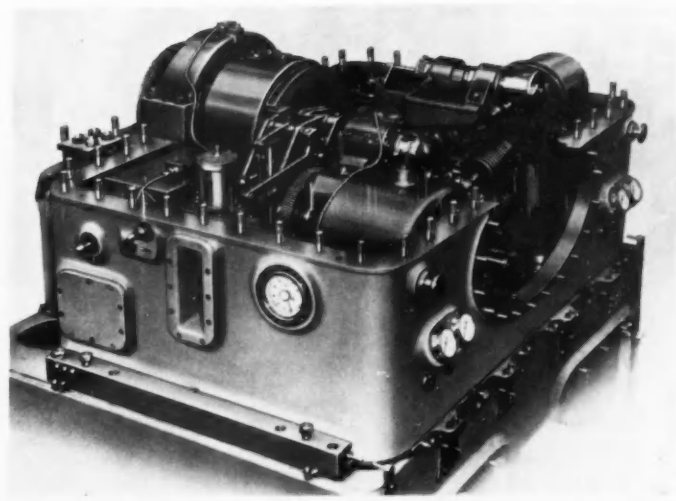


Pivotted clamps allow skew cuts to be made with this portable hacksaw.

IMPROVED TURBINE PEDESTAL

The " front end pedestal " of a turbine supports one end of the high-pressure cylinder and houses the bearing which supports the corresponding end of the turbine rotor. It has to accommodate longitudinal expansion and yet maintain correct axial location and concentricity. The latest form developed by Metropolitan-Vickers Electrical Company, Limited, Trafford-park, Manchester, 17, is shown in the accompanying illustration. In addition to the combined thrust and journal bearing, the casing also houses the two eccentric ring safety governors, the emergency trip gear, the governor relay gear, the speeder gear and the speeder gear operating motor, oil strainer, eccentricity indicator, axial movement indicator, electric tachogenerator and all interconnecting oil piping.

The mechanically-driven double-faced tachometer mounted on the top of the earlier pedestal has been replaced by two separate electric tachometer dials, each mounted in an antivibration housing in the side of the casing, and powered from the tachogenerator driven from the end of the turbine-speed pinion in the governor drive gearbox. Immediately below one of the tachometer dials is the oil sight box, and also on this side of the casing is the " open-shut " control for the governor valve sensitive oil. On the other side of the casing, in addition to the second tachometer dial, are the emergency trip-and-reset hand lever and the selector lever for the two eccentric-ring safety governors, and the hand control for the Auto-Klean strainer. On the front of the casing are the instruments registering axial movement, jacking oil pressure, governor oil pressure and oil drain temperature.



The Metro-Vick turbine front-end pedestal has been re-designed for improved convenience and appearance.

THE FRENCH AIRCRAFT SCENE

(2) TRANSPORT AND COMMUNICATIONS AIRCRAFT

In last week's issue of ENGINEERING, we described some of the recent developments in France's programme of combat aircraft and missiles. This week we deal with transport and communication aircraft and engines.

In the field of transport aircraft, France has pioneered two developments—the rear-engined jet air-liner and the high aspect-ratio wing. The latter has led to an Anglo-French agreement between F. G. Miles Limited, Shoreham, Sussex, and the Hurel-Dubois Company, and the formation of a new company in England, H.D.M. Aviation Limited, to exploit the Hurel-Dubois wing.

HIGH ASPECT-RATIO AIRCRAFT

The first product of the Miles-Hurel-Dubois collaboration is the HDM 105 experimental light-transport aeroplane—which consists of a Miles Aerovan box-type fuselage, with rear-loading doors, fitted with a Hurel-Dubois strut-braced high wing, with a span of 75 ft. 4 in., and an aspect ratio of 20·4. The gross area of the wing and lift struts is 388 sq. ft. The aircraft is 34 ft. 4 in. long and has a height of 13 ft. 11 in. The HDM 105 is of composité construction, the wing being made in aluminium alloy with a single spar, whereas the Aerovan fuselage is of wooden construction, and fitted with metal tail-booms.

The aircraft has a fixed tricycle undercarriage, the nosewheel being steerable. Slotted flaps and Frise-type ailerons are fitted. It is powered by two 155 h.p. Blackburn Cirrus Major III engines driving fixed-pitch wooden airscrews. At the maximum take-off weight of 6,170 lb., a distance of less than 420 yards is required to clear a 50 ft. obstacle. The initial rate of climb is 650 ft. per minute, falling to 500 ft. per minute at 5,000 ft. With one engine out of action, the rate of climb at 5,000 ft. is 65 ft. per minute. (The original Miles Aerovan, with conventional wing form, had no performance at all on one engine.) The cruising speed is said to be about 120 m.p.h.

From the HDM 105, the Miles brothers have developed a design study for a larger all-metal box-type transport aircraft to carry 16 passengers, or a car, or 1½ tons of freight from airstrips near city centres. It is to be powered by two Lycoming engines and will cruise at 130 to 150 m.p.h. Another possible development, the HDM 107, is intended to be a turbo-propeller military aircraft.

La Société de Construction des Avion Hurel-Dubois, Route de Verriere, Meudon (S et O.) have orders for eight H.D. 34 high-aspect-ratio photographic-survey aircraft for the Institut Géographique National. These aircraft are modified versions of the HD 32 airliner seen at the previous salon (ENGINEERING, July, 24, page 801, 1955)—which itself has now become the HD 320-01, with two Wright engines replacing the original Pratt and Whitney engines.

The specification for which the HD 34 has been constructed includes the following performance requirements:

(1) A 7-hour mission to be flown at 9,800 ft. at a cruising speed of 124 m.p.h. carrying 5,730 lb. of photographic equipment; (2) an 8-hour mission at 16,400 ft. at 173 m.p.h. carrying 5,730 lb. of photographic equipment; (3) an 8-hour mission at 23,000 ft. at 155 m.p.h. with 1,875 lb. of equipment. The equipment installed in the cabin of the HD 34 comprises two vertical cameras at the forward end, with 32 spare reels carried along the starboard side of the cabin, and two oblique cameras in the aft end, just forward of the rear cabin bulkhead. Modifications to the airframe include the fitting of a transparent nose, which lengthens the fuselage slightly; a rearranged cockpit; the installation of a retractable nosewheel to give a clear view forward; and an increased fuel capacity of 1,320 gallons. Two 1,525 h.p. Wright 982 C9 HE1 engines are installed, as in the HD 321 prototypes, and the take-off weight is 42,320 lb.

AIRLINERS AND CARGO CARRIERS

The *pièce de resistance* of the previous Salon in 1955 was, almost certainly, the Caravelle airliner by Sud Aviation. Two prototypes are now flying, one being in the United States on a demonstration tour, for which purpose the manufacturers are highlighting the low noise level, ensured by the tail location of the two Avon engines, by relaying " Mozart while you fly " over cabin loudspeakers. The third prototype, nearly complete, is to undergo pressure-fatigue tests in a water tank, and the fourth will be submitted to static-strength tests. The first production machine is due to be delivered to Air France—who have 12 on order—next year. In its tourist layout, the Caravelle will carry 80 passengers over a stage distance of 1,610 statute miles at a cruising speed of 500 m.p.h. In its first-class configuration, 64 passengers can be carried over 1,850 statute miles. At the Paris Salon, a mock-up of the cabin of the Air France version of the Caravelle was on view to the public; we hope that British designers of aircraft cabin interiors took the opportunity to look at it, and that they will derive some inspiration from its gay décor.

A development of the Nord 2501 Noratlas military cargo aircraft—now in service in the French Air Force and on order for the German air force—which is arousing interest among civil operators as well as the armed forces, is the Nord 2502 which, in addition to the two main SNECMA Hercules engines, has two 880 lb. thrust Marboré jet engines, one at each wing tip, to " boost " the take-off and enable the aircraft to be operated from smaller fields. Four of these aircraft, with an all-up weight of 48,400 lb. and a payload of 16,900 lb., and a still-air range of 1,800 miles, are already in service on the Central African routes of the French independent airline U.A.T., and three more are on order. A further derivative, the Nord 2506, has in addition an undercarriage specially designed for rough surfaces with poor load-bearing capacity, and high-lift flaps. A naval version, the Nord 2504, is on order for the Navy, fully equipped for training all crew members of an anti-submarine aircraft; and the Nord 2507, which is on order for search and rescue work on land or sea, with two lateral observation " bubbles," search radar, and parachutable rescue gear, dispatched through a door in the floor at the rear of the fuselage.

Avions Max Holste, 48 Rue Vivienne, Paris, are following up their successful light-transport aircraft, the Broussard, of which some 350 have been ordered for the French services—air force, army and navy—and 10 for the Argentine, with a light passenger-transport aircraft, the Super Broussard. A full-scale mock-up was on view at le Bourget. It is to be a high-wing all-metal monoplane powered by two 600 h.p. Pratt and

(Right) The Anglo-French HDM 105 comprises a Miles Aerovan fuselage with a Hurel-Dubois high aspect-ratio wing. H.D.M. Aviation.

(Below) The two prototype Caravelle airliners. Sud Aviation.

The Nord 2502 transport has two Marboré turbojets at the wing tips to boost take-off performance.

The Dutch Fokker Friendship airliner, powered by two 1,600 h.p. Rolls-Royce Dart 511 propeller turbines, appeared at le Bourget under the auspices of Louis Breguet.

Whitney R1340 engines, with semi-retractable undercarriage, and is designed to carry 14 to 17 passengers at a cruising speed of about 200 m.p.h. The maximum still-air range of 1,300 miles.

Another light aircraft that has attracted export orders as well as a contract for 50 machines for the French armed forces is the Paris 760 twin-jet four-seat communications aircraft designed by Société Morane-Saulnier, 3-5, Rue Volta, Puteaux, and powered by two 880 lb.-thrust Turboméca Marboré engines. It has a cruising speed of 350 m.p.h. Forty-eight Paris aircraft have been ordered by the Argentine to be assembled at the State Aerotechnical Institute at Cordoba, with an option on a further 52.

Although not a native of France, the Friendship airliner designed and constructed by Fokker N.V. Koninklyjke Nederlandse, Vliegtuigenfabriek Schipholr, Amsterdam, is now, so to speak, a relation-by-marriage as a result of the Fokker-Breguet link-up, and it was demonstrated under the auspices of the Breguet company at le Bourget. For this reason, and also because it seems likely to capture the DC-3 replacement market, we include a brief description here. It is gratifying to note that the Friendship has British engines—two 1,600 h.p. Rolls-Royce Dart 511 propeller turbines—and makes extensive use of the British Redux metal-to-metal bonding process in its primary structure. Considerable use is also made of glass-fibre laminates, mainly in the secondary structure.

The Friendship is designed to carry 32 to 40 passengers over short and medium stages, at a cruising speed of 275 m.p.h., and has an all-up weight of 34,500 lb. It will take off and clear a 50 ft. obstacle in about 1,200 yards, and the single engine performance is said to be exceedingly good. The wing span and area are, respectively, 95 ft. and 725 sq. ft.; the overall length is 76 ft. and the height is 27·5 ft.

HELICOPTERS

Sud Aviation has in production two helicopters of French design (as well as American Vertol H21 and Sikorsky 5.55 and S58 helicopters, under agreement), the five-seat shaft-driven turbine-powered SE3130 Alouette II, of which 200 are on order and 32 have already been delivered, the first Alouette squadron being formed at the end of February; and the two-seat cold-tip-jet SO1221 Djinn, 125 of which are on order, mainly for France but also for the Argentine, 25 having been delivered already to the French armed forces. The Djinn has recently taken from the Alouette the world altitude record for helicopters, which now stands at 27,730 ft. Both of these French helicopters have aroused great interest in the United States.

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ENGINEERING RECORDS AND RELICS IN LONDON

Newcomen Summer Meeting

The Summer Meeting of the Newcomen Society, which took place on June 4, 5 and 6, was held in London, to coincide with the centenary of the Science Museum, South Kensington, London, S.W.7, and the first visit of the meeting was to the Museum, where members and their guests were welcomed by the Director, Dr. T. C. S. Morrison-Scott, D.S.C. The party was then conducted round sections of the Museum, including the new electrical gallery where the latest display techniques were seen in use. The history of the Museum was the subject of a talk by Mr. F. Greenaway, M.A., after the annual dinner of the society on the following evening.

From the Museum the party went on to a much younger institution, the Historical Records Department of the British Transport Commission, at 66 Porchester-road, London, W.2, where they saw the remarkable progress made by Mr. L. C. Johnson, the Commission's archivist, and his assistants, in assembling, cataloguing, repairing where necessary, and storing, the vast collection of books and documents belonging to the Commission and its predecessors, the railway, canal and other transport companies. Mr. Johnson explained that his department is essentially a functional one, providing records of all kinds as required for the day-to-day working of the Commission's many business activities, but he added that bona fide students of transport history are welcomed, and facilities can be provided for them to carry out research work.

The programme continued with visits to the works of W. and C. Nightingale, Limited, 70/74 Old-street, London, E.C.1, and to the General Post Office at Mount Pleasant, E.C.1. At the works in Old-street a compound beam engine, built by Robert Wood and Sons, Leeds, was seen. This engine, though it has not been used for some years, has been maintained in excellent condition by its owners and was, in fact, with their enthusiastic co-operation, seen in steam. It has a high-pressure cylinder of 12 in. bore and 32¾ in. stroke, the corresponding figures for the low-pressure cylinder being 24 in. and 48¼ in. respectively.

At Mount Pleasant the party was privileged to see the unique private underground railway, 6½ miles long, which connects several G.P.O. sorting offices and two main line railway termini. It carries some 42,000 mail bags a day in 2 ft. gauge electric trains, which travel at a maximum speed of 35 m.p.h., and are run under automatic control, without crews. The line was opened for traffic in 1927.

Continuing the railway theme, the party made the last visit of the day to Euston Station where some cast-iron stanchions and roof trusses of about 1838 were seen, and a brief visit was made to the "Transport Treasures" exhibition in the old shareholders' meeting room. Here, Mr. John H. Scholes, curator of historical relics, British Transport Commission, explained briefly the Commission's policy in regard to historical machines and other items in their possession, and told members of the Society that the present small exhibition, covering as it does all aspects of the Commission's trading activities, gives a general idea of the larger schemes they have in mind.

On the morning of the second day the steam pumping plant preserved at Kew Bridge by the Metropolitan Water Board was seen, by permission of Mr. H. F. Cronin, C.B.E., the Board's chief engineer. The steam plant, which was in active use until 1943/4, includes a 64 in. Boulton and Watt beam pumping engine of 1820, a 64 in. Maudslay Sons and Field of 1838, a 70 in. Harvey Bull type of 1856, and a 90 in. Sandys Carne, Vivian engine of 1846. All are fine specimens of their type and age, but pride of place belongs to a 100 in. Harvey of 1869, which used to pump 10 million gallons of water a day. This engine, like all the others at Kew Bridge, is in an excellent state of preservation, and is the largest Harvey engine now in existence in this country.

A very different type of plant was seen during the afternoon of the second day, when the works of Kodak, Limited, Wealdstone, were visited. Here the party saw the manufacture and assembly of cameras, printing and box-making, and some of the process work done on photographic paper. This work has to be carried out in dark rooms, and engineers in the party were interested in the question of maintenance of production machinery under these conditions. From the production departments the party proceeded to the Kodak Museum, where, under the guidance of Dr. Schultz, the curator, they were given an outline of the history of photography and photographic apparatus.

The last day of the meeting was occupied with visits to the Royal Mint, Tower Hill, where the die-sinking and coining departments were seen, and to the nearby tube tunnel under the Thames, the first of its kind in the world. It was opened in 1869, not, as the inscription on the entrance says, in 1868. The tunnel now accommodates hydraulic and other water mains.

Finally, the party proceeded to the National Maritime Museum, Greenwich, passing on the way the old china clipper "Cutty Sark," which has been repaired and re-rigged and is to be preserved in a dry dock adjoining Greenwich Pier. No formal programme had been arranged at the Maritime Museum, members visiting the various exhibits according to personal choice.

ATOMIC REVIEW

Now Entertain Conjecture

THE cost of power from nuclear reactors depends on many factors. Soon, however, and bearing in mind the rising costs of fossil fuels, electricity derived from nuclear sources is going to be economical (so long as some of the costs for earlier nuclear research are not included). The cost factors that are considered, and the way in which these factors change with different reactor systems, was discussed by Mr. J. A. Jukes, economic adviser to the U.K.A.E.A., in a paper he read in April before the Information Conference on Nuclear Energy for Management, held by the O.E.E.C. in Paris. An abridged version of the paper is given below. Mr. Jukes's figures are based primarily on the experience gained by the U.K.A.E.A.; a corresponding survey based on American experience was reported in Atomic Review for April 12 (page 474).

Cost Factors

The outstanding economic advantage of nuclear power is that it is possible to make fuel costs low and this should be achieved in the early station. With later stations there are possibilities of achieving extremely low running costs. On the other hand, capital costs are likely to be high. In some ways the cost characteristics of nuclear power are more akin to those of hydro-electric plants than to conventional thermal plants, and this fact has an important bearing on the uses that are likely to be made of nuclear power.

Capital Costs

Although the capital cost per kW of a nuclear power station may vary greatly with the type of reactor, there are a number of general reasons why the cost is high. In the first place, in stations of the type so far in the design stage, the reactor only replaces the furnace of a conventional thermal station; it is still necessary to have a turbo-alternator and heat exchanger. The capital cost of a station of the gas-cooled graphite-moderated type recently ordered by the Central Electricity Authority and designed in accordance with the latest technological advances should be about £130 per kW. This may be compared with the cost of a conventional coal-fired station which could be built in the early 1960's for about £50 per kW.

The early reactors are likely to operate at considerably lower temperatures than present day conventional thermal plant, leading to poor steam conditions in the turbine, and thus to bulky turbines and to a higher cost per kW for the turbo-alternator than in a modern coal-fired plant. A rise in the working temperature will lead not only to an increase in the amount of heat that can be obtained from each ton of uranium but also to better steam conditions with smaller and less expensive turbines and boilers.

One possible way in which capital costs per kW might be reduced would be to superheat the steam in a superheater using coal or oil. If it were possible to do this conveniently the smaller size of the turbo-alternators per kW of capacity —they could be standard units—might lead not only to lower overall capital costs per kW but also to lower electricity costs. Expressed another way, superheating might make additional generating capacity using fossil fuels available at a relatively low cost per kW.

Whether superheating will be worth while will depend upon many factors. Its use may raise difficulties over the supply of oil or coal to the particular sites in question and certainly adds an additional operational complication and a further important siting restriction. Moreover, as steam temperatures in more advanced types of nuclear power stations are increased to a level approaching those achieved in the modern conventional stations, super-heating by fossil fuels will become less attractive. Some types of reactor, such as those using water under pressure, are, however, always likely to be limited in their temperature and in these cases it is more probable that the advantage of fossil fuel superheating will in many cases outweigh the complications involved in using it.

Cost of Initial Fuel

A nuclear station has the peculiar feature that it requires a large working stock of fuel. It will not operate until a full charge of fuel is in the reactor—a charge which may stay in the reactor for several years. This initial charge is expensive —the uranium required for one of the early reactors in the United Kingdom power programme will amount to several hundred tons and will cost, including fabrication into fuel elements, up to £5 million. This cost should be considered as a capital item—an investment in working stocks. As the uranium charge that is in the reactor when it is finally shut down will have a considerable residual value, it is not necessary to cover with depreciation the whole of the value of the charge, but interest should be paid on it. In the early United Kingdom stations the initial charge will cost about £30 per kW. As the heat rating of the fuel is increased in later stations with further development the cost per kW should come down.

Other types of reactor may require a smaller tonnage of uranium, but in many cases this will have to be enriched uranium which is much more expensive per ton. The highly rated reactors may also require special canning material for the fuel elements which will add to the cost.

Economies of Scale

All electricity generating stations show big economies of scale—the larger the station the lower the cost per kW; these economies of scale are likely to be even more marked with nuclear stations. Very big stations are suitable in countries with a big baseload and with a developed transmission network, but in many parts of the world, where the demand for electricity is lower, such large stations could not be accommodated economically in the supply system.

Unfortunately, not many countries exist which have the necessary demand to justify the installation of many large power stations that need to work at 75 per cent. load factor. The O.E.E.C. area is one of the few areas in the world where at the moment the necessary conditions exist, and as a result nuclear power has great immediate possibilities in it. Apart from Europe's shortage of fossil fuels and their high cost, it has a highly developed electrical grid network and a big electricity demand caused by the high general level of industrialisation.

United Kingdom Load Factor

In the United Kingdom, under the position so far as load factor is concerned, it is expected to be possible to operate all the 5,000-6,000 MW of nuclear capacity that is planned to be installed by 1965 at 75 per cent. load factor. By about 1970, however, the load factor of some of the nuclear plant should be lower, probably down to 65 to 70 per cent. Eventually, as nuclear capacity forms an increasing proportion of total capacity, the average load factor on nuclear plant will fall rapidly.

When interest rates are considered, arguments pass from physical factors to the less predictable fields of financial policy and institutional arrangements. Interest rates are widely different, complicated and, it might almost be said, irrational. The rate of interest chosen for planning purposes affects not only the choice between a nuclear and a conventional power programme, but also the choice between different reactor systems. A high interest rate will favour the system having a low initial capital cost even though it may be a high running cost system (that is, a system that uses enriched fuel). Low interest rates, however, favour the high capital cost, low running cost type of station such as those that are being built in the United Kingdom.

Another cost which has to be considered is the works costs—that is, the salaries and wages of staff and the average cost of maintaining the station. There is, however, no reason for believing that they will diverge much from the working costs of coal or oil-fired stations. The number of staff required is likely to be about the same and the station can be run by shift workers without a very high degree of skill. It seems reasonable, therefore, to assume that works costs will be about the same as they are at the moment for a good coal or oil-fired station—perhaps 10 per cent. of total generating cost, or 0·05*d.* per kWh.

Fuel Costs

The one cost factor in a nuclear power station which is closely dependent on the amount of electricity produced is the fuel running cost. The fission of one gram of fissile material releases the equivalent of 1,000 kW of heat for one day. Fission products also accumulate in the reactor which tend to poison the reactor and thus to stop the chain reaction. The fuel running cost is equal to the cost of providing the replacement fuel elements less any credit available for the fissile material or for any uranium contained in the used element.

Uranium Prices

The cost of the fuel elements will depend primarily on the cost of the uranium. As a general guide to the long-term price, that of concentrates may be taken as 10 dols. a pound of uranium oxide (U_3O_8). This figure corresponds with a uranium price of £10,000 a tonne. The cost of the extraction and purification from concentrates is comparatively small compared with that of the concentrates. The cost of preparing, by casting and machining, the required fuel element shapes—rods, plates or tubes—may, however, be considerably greater. Finally the fuel elements usually have to be clad or canned with some protective material and this may add significantly to their cost, even if common materials such as aluminium or magnesium are used; the cans will be much more expensive if beryllium or zirconium are used. These latter materials, however, have considerable advantages which should more than outweigh their additional cost under certain conditions. The price of complete natural-uranium fuel elements for nuclear power stations similar to the first commercial stations to be built in the United Kingdom will probably be in the order of something approaching £20,000 a tonne of uranium.

Some of the early reactors may require enriched fuel. This may be uranium at low enrichments (e.g. with the uranium 235 concentration increased from 0·7 per cent. up to, say, 1·5 per cent.) or fissile material of high concentration. The cost of enriched uranium depends on the enrichment, but because of the high cost of separation in a diffusion plant even small amounts of enrichment add considerably to the cost. The only published prices for uranium 235 in the world to-day are those recently published by the U.S.A.E.C. for its sales. This ranges from 5·74 dols. per gram for 0·74 per cent. material (i.e. almost natural uranium) to 17·07 dols. per gram for 90 per cent. material. If supplies can be obtained from the United States these prices are the ones to take, but if other plants are used prices may be considerably higher; for instance, the United Kingdom diffusion plant at Capenhurst is much smaller than the United States plants and uses electricity costing about three times as much—giving a final cost of the product well above the United States price. The cost of enrichment in the form of plutonium will depend upon many factors which cannot at present be estimated; but in those cases where a suitable technique for the use of plutonium is developed it is

expected that the total cost of enrichment will be rather less than with uranium 235.

These costs of enrichment show that even quite small amounts of enrichment will increase the cost of fuel per ton—both for the initial charge and for replacement charges—very considerably. Its use, however, provides many additional possibilities in the design and operation of reactors; some moderators, such as ordinary water, can only be used with enriched fuel; and its use in gas-cooled graphite-moderated reactors should enable higher heat ratings and higher levels of irradiation to be obtained. In particular, although it may lead to higher fuel replacement costs, it should enable the capital cost to be reduced.

Thermal Efficiency

Fuel costs will also be affected by the thermal efficiency of the nuclear station. This depends primarily on the temperature attainable in the reactor. Early gas-cooled stations will have an efficiency of between 25 per cent. and 28 per cent., determined by the comparatively low gas-outlet temperatures of about 400 deg. C. However, with development the temperatures will be raised, e.g. by the use of beryllium canning, and higher thermal efficiencies will become possible. Reactors dependent upon the use of water under pressure are limited to lower temperatures and thus lower thermal efficiencies. They may, however, as already mentioned, make use of an oil-fired superheater—in which case the overall thermal efficiency will be higher but only about two-thirds of the heat will be supplied by nuclear energy.

Three main factors—cost of the fuel elements, the irradiation level and the thermal efficiency—together make up gross fuel replacement costs. The aim of low fuel costs will be achieved by an optimum combination of the three factors. Fuel replacement costs are expected to be in the order of 0·2 to 0·25*d.* per kWh for early gas-cooled reactors. Thence forward they may be expected to show a gradual fall.

Value of Plutonium

In order to arrive at the net fuel costs of a nuclear power station credit has to be allowed for the value, if any, of the irradiated fuel. This will contain plutonium (or uranium 233 in thorium systems). Now plutonium is a fissile material which in many ways is similar to the very expensive separated uranium 235; it can therefore be used as a reactor fuel. The value of the plutonium by-product will depend upon the extent to which it can be used as a substitute for uranium 235, either to supply enrichment or merely to replace the uranium 235 contained in natural uranium.

Although the value of plutonium is therefore related to the costs of obtaining uranium 235 in various forms, there are still many uncertainties over the exact methods of using it and much development work, which is already under way, needs to be completed. Plutonium is likely to be most valuable in providing slight enrichment for thermal reactors. It will also be useful as the main fuel charge for fast reactors. If it is not wanted for more valuable purposes it should be possible to re-cycle it—to use it as a fuel in the reactor which produced it. Because of the uncertainties over its method of use it is usual to be cautious in estimating its value and to allow only a low figure.

In calculating the value of the irradiated fuel elements account must be taken of the cost of extracting the plutonium from the used fuel. This should be a few pounds a gram but should fall with later developments and with an increase in the throughput of the chemical plant. Taking into account the processing cost, it is expected that the irradiated fuel from the early United Kingdom commercial reactors will be worth at least £5,000 a tonne; in the early years, when enriched material is scarce, it may well be worth rather more. This £5,000 a tonne has therefore to be deducted from the fuel replacement cost to obtain the nett fuel cost.

Total Costs

On the basis of the detailed cost factors given above it is now possible to give illustrative figures for total costs. The Table shows the estimated cost of power from nuclear stations similar in type to those now being built for the United Kingdom Central Electricity Authority. The total cost comes out at a figure which is between 0·6 and 0·7*d.* a kWh.

TABLE.—*Approximate Cost of Electricity from Nuclear Stations of the Type Ordered by the United Kingdom Electricity Authorities*

—	Pence per kWh sent out
Amortisation (capital charges at 8 per cent.)	0·37 to 0·40
Interest on initial fuel charge (5 per cent.)	0·05 to 0·06
Fuel replacement cost (gross)	0·22 to 0·25
Works costs (about)	0·05
Total gross cost	0·69 to 0·76
Plutonium credit (about)	0·07
Total net cost (say)	0·6 to 0·7

The cost of electricity from nuclear power in other O.E.E.C. countries will vary according to circumstances and particularly with the rate of interest at which the electrical authorities can borrow. In the United Kingdom there is a rate of interest appropriate for long-term Government finance. Likely figures for a typical highly industrialised continental O.E.E.C. country are slightly higher.

Sodium Reactor Experiment

The Sodium Reactor Experiment (SRE) which started operation on April 25 in Los Angeles (see Atomic Review, May 17, page 636) represents a concept for producing high-temperature high-pressure steam without the use of a pressurised coolant. It is a graphite-moderated sodium-cooled reactor, the sodium remaining a liquid at power-plant temperatures and atmospheric pressure.

The graphite, which serves as both moderator and reflector, is canned to prevent it from coming into contact with the sodium coolant as this would result in sodium being absorbed into the pores of the graphite and cause excessive neutron losses. A considerable amount of metal is required to clad the graphite and it was therefore impracticable to use stainless steel for the purpose, since this again would capture too many neutrons. Instead, the graphite is protected by zirconium sheet.

The core and reflector assembly is formed from zirconium-clad hexagonal graphite columns each 10 ft. high (6 ft. for the moderator and an additional 2 ft. top and bottom for the reflector) and slightly less than 11 in. across the flats. The can assemblies are arranged in a triangular lattice with an 11 in. centre to centre spacing, leaving a 0·17 in. gap between cans through which sodium coolant flows. A total of 119 of these canned graphite-moderator units are contained in the stainless-steel reactor vessel, 11 ft. in diameter and 19 ft. high. Each of the units in the core region (43 altogether) is penetrated along its axis by a zirconium tube 0·035 in. thick and 2·80 in. in diameter, which forms a fuel element and coolant channel. Interstitial channels, of which there are 17, are occupied by control elements or used for experiments.

One of the problems associated with canning the graphite is the gas pressure which might be produced as a result of prolonged operation at high temperatures and under irradiation. The zirconium side panels are thin (0·035 in.) and

Fig. 1 View of the Sodium Reactor Experiment (SRE), a sodium-graphite pilot-plant reactor located in the Santa Susana mountains near Los Angeles. It has been built by Atomics International under the United States Atomic Energy Commission's five-year programme and will produce 20 MW (heat).

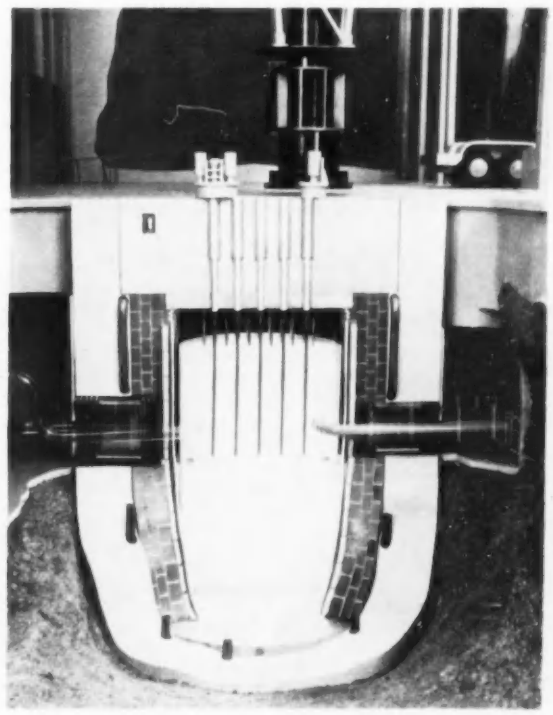

Fig. 2 Model of Sodium Reactor Experiment, showing core and, to left and right, ducts for the liquid-sodium coolant.

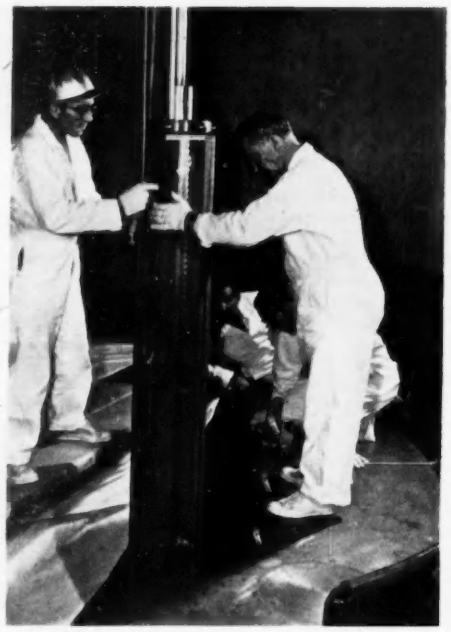

Fig. 3 Moderator can being lowered into SRE. The graphite moderator is contained in zirconium alloy cans to protect it from the action of the liquid sodium. Each unit is 10 ft. long.

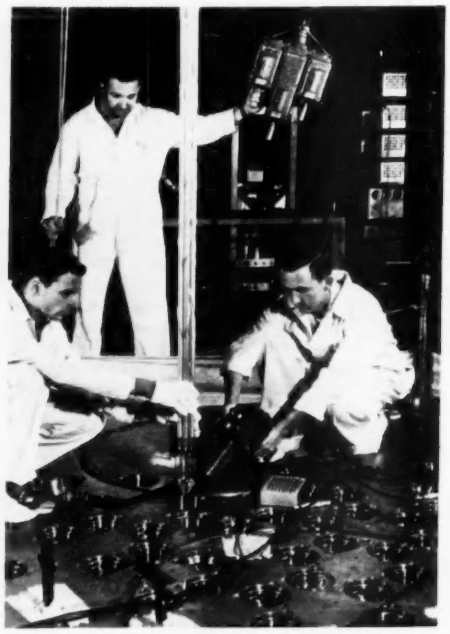

Fig. 4 Fuel element comprising slugs of uranium contained in stainless-steel sheaths being lowered into SRE during an experimental loading. Each slug is 0·75 in. in diameter.

flexible, and it is only safe to operate with some external pressure collapsing the panels against the graphite since, at high temperatures, the zirconium expands away from the graphite leaving the top can head (of 0·10 in. zirconium) unsupported. Provision has therefore been made to control the pressure inside the can by means of a vent tube extending from the bottom of the assembly out through the top head into the helium atmosphere above the free surface of the sodium in the core tank pool. At the bottom of the vent tube and resting on the bottom can head is a small cup to collect any sodium which might find its way into the unit as a result of diffusion of sodium vapour and pressure fluctuations.

Each fuel element consists of a cluster of seven rods separated by a 0·092 in. diameter wire spiral. The rods themselves contain a 6 ft. high column of 6 in. uranium slugs (2·78 per cent. U-235 by weight) in a stainless-steel jacket tube, thermally bonded by NaK alloy. The slugs are 0·750 in. in diameter, the jacket tube is 0·010 in. thick, and the NaK annulus 0·010 in average thickness.

The control and safety units (four of each) are completely self-contained so that no sodium or sodium vapour can come into contact with the moving mechanical parts. Each stainless-steel thimble assembly holds 14 hollow boron-nickel alloy cylinders, 2·5 in. outside diameter, $\frac{3}{8}$ in. thick and 4 in. long ($2\frac{5}{8} \times \frac{3}{8} \times 4$ in. for the safety units), with the drive mechanism inside the cylinders. The thimble assemblies extend from the top of the rotatable shield above the reactor to a point just below the core, a total distance of $23\frac{1}{2}$ ft.

The reactor is located below ground with the upper surface of its 5 ft. thick concrete top shield at floor level. Surrounding the core tank is a stainless-steel thermal shield $5\frac{1}{2}$ in. thick, and an outer tank intended as an emergency means of containing the sodium in the event of a leak in the core tank. The outer tank is surrounded by approximately a foot of thermal insulation. This, in turn, is contained in a tank called the cavity liner which serves as a form for the concrete foundation and aids in the removal of heat, toluene being circulated through coolant pipes welded on its outer surface.

The liquid sodium used to cool the reactor core becomes radioactive, and a secondary non-radioactive sodium system is therefore used to transfer heat to the steam-generating plant. Both the primary and the secondary system have two separate circulating loops; a main loop capable of transferring 20 MW of heat and an auxiliary loop capable of transferring 1 MW of heat. The auxiliary circuit is operated simultaneously with the main circuit to ensure some heat removal in the event of component failure in either circuit. Inlet lines from the primary loops enter the core tank above the graphite assemblies and extend vertically downward in double-walled pipes to discharge into a plenum between the bottom of the core tank and the grid plate supporting the moderator. This sodium, at a temperature of 500 deg. F., then passes up through the fuel-element channels and discharges into a pool 6 ft. deep, having a mean temperature of 960 deg. F. Inlet and outlet temperature for the secondary coolant circuit are 440 deg. F. and 900 deg. F., respectively. It was originally intended to dissipate the 20 MW of heat produced by the reactor in an air-blast cooling system, but it was later decided to make use of this output and a 7·5 MW turbine has been installed by Southern California Edison Company. Steam is generated at 600 lb. per sq. in. and 825 deg. F. The main aim of the SRE, however, is to obtain technological data and operating experience on sodium-cooled graphite-moderated reactors. This will be used in building the 75,000 kW (electrical) sodium-graphite power plant proposed by the Consumers Public Power District of Nebraska, due for completion in 1960.

Critical Assembly

An operating licence was issued to Babcock and Wilcox on March 20 for its critical experiments facility near Lynchburg, Virginia. A critical assembly differs from a reactor in that the arrangement of the fuel elements and other components is not permanent, but may be re-arranged without difficulty. It operates at or near zero power, so that little radiation is emitted, comparatively thin shields are sufficient, and the components themselves do not become highly radioactive. The Babcock and Wilcox facility can thus be used to test a variety of fuel elements and cores, although each planned group of experiments has to be submitted to the A.E.C. for a safety evaluation. The operating licence, however, included authorisation to perform critical experiments in connection with the 275 MW electrical pressurised water, thorium-uranium converter reactor being built for Consolidated Edison by Babcock and Wilcox at Indian Point. The core mock-up uses approximately 275 kg. uranium 235 in the form of oxide powder dispersed in polyethylene plastics tape sandwiched between thorium converter plates; and the initial series of tests, representing the first use of large quantities of thorium in connection with a power plant project, has already been completed.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

SOUTHAMPTON
Annual General Meeting. Southampton Branch. Polygon Hotel, Southampton. Thurs., June 20, 7 p.m.

Building Centre

LONDON
Film: "Timber Decay in Buildings," exhibited by Richardson and Starling, Ltd. Wed., June 19, 12.45 p.m.
Film: "Zinc in Building," exhibited by the Zinc Development Association. Wed., June 26, 12.45 p.m.

Combustion Engineering Association

CARDIFF
"The Reduction of Smoke and the Efficient Control of Combustion by Instrumentation," by W. R. L. Kent, at 10.30 a.m. "The Effect of Coal Characteristics on the Operation of Mechanical Stokers," by D. C. Gunn, at 2.30 p.m. Welsh Region. Park Hotel and Whitehall Rooms, Cardiff. Wed., June 19.

Incorporated Plant Engineers

CHESTER
"New Developments in Chemical Engineering Materials," by E. Warde. Merseyside and North Wales Branch. Stafford Hotel, City-road, Chester. Thurs., June 20, 7.15 p.m.

Institution of Electronics

LONDON
"Theoretical Problems of Television Astronomy," by Dr. P. B. Fellgett; and "The 1956 Opposition of Mars," by B. V. Somes-Charlton (with films). Beveridge Hall, Senate House, University of London, W.C.1. Fri., July 5, 6 p.m. (Tickets required.)

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
Centenary Celebrations, Tues., June 25, to Thurs., June 27. Presidential Address by Sir Harold E. Yarrow, Bt.; "A Short Biography of the First President, Professor W. J. Macquorn Rankine," by Professor J. Small; and "Nuclear Power for Ship Propulsion," by Dr. S. L. Smith and Dr. J. E. Richards, at 10 a.m. Various works visits in the afternoon. Banquet in St. Andrew's Halls, Granville-street, Glasgow, at 7 p.m. Tues., June 25.
All-day excursion to the Firth of Clyde, Wed., June 26.
All-day works visits and excursions. Reception by the Lord Provost of Glasgow, in the City Chambers, George-square, Glasgow, at 7.30 p.m. Thurs., June 27.

Institution of Mining and Metallurgy

LONDON
"Mechanisms of Collector Adsorption and Dynamic Attachment of Particles to Air Bubbles as Derived from Surface-Chemical Studies," by J. Leja; "Flotation of Soluble Salts," by J. Rogers; and "The Assessment of Flotation Results," by J. C. Nixon and D. N. Moir. Geological Society's apartments, Burlington House, Piccadilly, W.1. Thurs., June 20, 5 p.m.*

Royal Meteorological Society

LONDON
"Airflow Over an Isolated Hill," by R. S. Scorer; "Waves in the Lee of an Isolated Hill," by R. S. Scorer and M. Wilkinson; "Airflow Over Mountains: the Lee-Wave Amplitude," by G. A. Corby and C. E. Wallington. Wed., June 19, 5 p.m.*

Royal Society

LONDON
The Bakerian Lecture: "The Elementary Particles," by C. F. Powell. Thurs., June 20, 4.30 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury square, London, W.C.1. (LANgham 5927.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum-5400.)
Combustion Engineering Association, 6 Duke-street, St. James's London, S.W.1. (WHItehall 5536.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institution of Electronics, 78 Shaw-road, Rochdale, Lancs.
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)

In Parliament

ADVANCED TECHNOLOGY IN NORTH EAST ENGLAND

Facilities for the teaching of advanced technology in the north east of England were referred to in the House of Commons last week. Mr. F. T. Willey (Labour) and Captain G. R. Chetwynd (Labour) pressed the Parliamentary Secretary to the Ministry of Education to make a statement on proposals for setting up a college for that purpose.

Sir Edward Boyle, Bt., stated that, at the request of a previous Minister of Education, the Northern Advisory Council for Further Education had recently submitted a report on the pattern of technical education in the northern region, with particular reference to the establishment there of a college of advanced technology. The present Minister, Lord Hailsham, was now studying the matter in relation to that report and had visited the area.

The Council were unanimous in their view that such a college should be established in the region as soon as possible. They reviewed various proposals and, in particular, suggestions for either building a completely new college or of designating an existing college. They were unable to put forward a specific recommendation, but recorded their conviction that all the authorities would accept and support any decision that was reached on the matter. Lord Hailsham agreed that an advanced technology college should be established in the region promptly, but felt that no existing college was at present suitable for designation. A large-scale programme was required to provide the necessary conditions. Lord Hailsham had carefully considered whether this programme should be devoted to the setting up of an entirely new college, but he had decided that, apart from the extra time involved, the establishment of a new college outside the existing industrial centres would possess no merits.

Lord Hailsham had accordingly decided to request the Newcastle Local Education Authority to undertake the development work necessary at the Rutherford Technical College so that it might become, in due course, a college of advanced technology. The Ministry's officers would begin negotiations with the Authority forthwith regarding the erection of buildings and the recruitment of staff.

SUNDERLAND TECHNICAL COLLEGE

It was essential that the college of advanced technology, Sir Edward said, should take its place in a regional scheme in which the other colleges in the area, and particularly the Sunderland Technical College and the Constantine Technical College at Middlesbrough, would play their full part. Lord Hailsham would be requesting the Authority, among other matters, to review their scheme of government for the Rutherford Technical College, so as to afford representation to certain other authorities in the region. He also proposed to ask all the local education authorities to consider, through the medium of the Northern Advisory Council, what amendments would be necessary in the existing regional scheme of technical courses.

The Sunderland Technical College, as a regional college, would continue to make its distinctive contribution to the provision for technical education in the region, and it was hoped that the Constantine College might also develop into a regional college in the near future. In both cases, there existed plans, based on regional college status, for the expansion of accommodation, the development of new courses and the reconstitution of the governing body. Lord Hailsham's decision about a college of advanced technology in no way militated against those plans and it was to be hoped that the local education authorities would do their best to push on with their proposals as urgently as possible.

DE-SALTING OF SEA WATER

Sir Roland Robinson (Conservative) inquired about the discussions which had taken place between the Department of Scientific and Industrial Research and Dutch scientists on processes for drawing dissolved salts out of sea water. He was told by Mr. Harmar Nicholls, the Parliamentary Secretary to the Ministry of Works, that, following the small-scale experimental work, equipment on a larger scale had been designed and made, and that a long-term trial on the removal of salts from sea water was being carried out at Scheveningen. It was too early to make firm estimates of production costs, but the work so far accomplished indicated that processes other than that of electro-dialysis (such, for example, as distillation) were likely to be the cheaper for the treatment of sea water. On the other hand, electro-dialysis was expected to be the most economic process for brackish waters, such as were found in many parts of the world.

Mr. Nicholls, who was replying on behalf of Lord Home, the Lord President of the Council, whose representative he is in the Commons, stated that the countries collaborating in this work were The Netherlands, the United Kingdom, France, Australia, South Africa, Israel, Greece and Pakistan.

DISCHARGING LARGE OIL TANKERS

The House was informed by Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, that he had had discussions with the interests concerned with Milford Haven, who were seeking powers for providing discharging facilities there for oil tankers of up to 100,000 tons deadweight. At Southampton, plans were going forward to enable oil tankers of up to 65,000 tons deadweight to be handled. On the Clyde, a new jetty was to be provided capable of accommodating ships of up to 100,000 tons deadweight. On the Mersey, a new berth was contemplated which would be capable of taking ships of up to 65,000 tons deadweight, or of ships of up to 100,000 tons deadweight, with a draught restriction. So far as the Thames was concerned, Mr. Watkinson told Commander J. F. W. Maitland (Conservative) that the Port of London Authority and the oil companies were discussing the amount of dredging which would be necessary to raise the present limit of 45,000 tons deadweight. A number of other sites were also being surveyed by the interests concerned.

DRY DOCKING FOR OIL TANKERS

A suggestion that floating dry docks should be constructed to accommodate large oil tankers, in order to save time on the cleaning and repairing of these vessels, was put forward by Mr. S. S. Awbery (Labour). He also asked the Parliamentary Secretary to the Admiralty to hasten his consideration of the scheme to deal with this matter, in view of there being only two dry docks in this country capable of taking 100,000 ton oil tankers. Particulars of the scheme, Mr. Awbery said, had been sent to the Admiralty last year.

On these points, Mr. T. G. D. Galbraith, Civil Lord of the Admiralty, said that the use of floating docks would not save time on the cleaning, painting and repairing of the ships. Floating docks would require steel which otherwise could be used in the construction of ships. Mobility, which was their chief asset, was restricted by the small number of deep water estuaries in Britain. He understood that the other matter related to a scheme for harbour developments at Milford Haven which had been sent to certain Government Departments. Private Bills were now before Parliament for additional facilities at the Haven.

British Air Service to South America

Pressed by Mr. Anthony Hurd (Conservative) to restore a British air service to South America at the earliest possible date, Mr. Watkinson referred to the reply he had given to Mr. Hurd last August, wherein he had stated that the 18 long-range Britannias on order were intended to provide for the western routes, including that between the United Kingdom and South America. The British Overseas Airways Corporation were now about to send representatives to South America in connection with a re-examination of the prospects of that route.

Tyne Tunnel Prospects

Replying to Dame Irene Ward (Conservative), who wanted the Minister of Transport to include the Tyne Tunnel in the Government's construction plans for 1958-59, Mr. Watkinson said that he could not add to his present programme for that financial year. He also told Dame Irene that the Dartford-Purfleet and Tyne tunnels would have different diameters. It would not be practicable, therefore, to employ the shields now being used at Dartford for the construction of the Tyne Tunnel.

Automatic Train Control

Mr. Watkinson said that, during the past twelve months, the length of track on which automatic train control arrangements operated had been increased from 77 to 210 miles. Since receiving his final approval of the system in November last, the British Transport Commission had been forging ahead with its plans to provide the equipment on all the main traffic routes as quickly as possible. It was the Commission's intention, he told Mr. Gerald Nabarro (Conservative), to equip more than 1,300 miles of track, together with some 10,000 locomotives, by the end of 1962. Mr. Watkinson pointed out, in answer to an interjection by Mr. Ernest Davies (Labour), that the Great Western Railway was the pioneer of automatic train control and had had it in operation before nationalisation.

Atomic Energy Station for Wales

The Central Electricity Authority is investigating a number of sites in North Wales with a view to the erection there of an atomic energy generating station. It will, however, be some months before the Authority has acquired sufficient data to enable it to make definite proposals, according to an answer given by Mr. David Renton, the Parliamentary Secretary to the Ministry of Power, to Mr. T. W. Jones (Labour).

Hurrying the Forth Road Bridge

It was urged by Mr. Arthur Woodburn (Labour) that an early start should be made with the construction of the Forth road bridge. He pointed out that some preliminary action, such as work on the roads which would join up with the bridge, would be generally welcomed as a sign that a commencement was being made. The Secretary of State for Scotland, Mr. John Maclay, said that he understood that the consultant engineers employed by the Forth Road Bridge Joint Board were making good progress with the preparation of detailed plans. The Joint Board had received his authority to invite tenders as soon as those plans were completed. As previously stated, he hoped that the actual work of construction might be begun in the summer of next year.

Money Markets in the Commonwealth

Attention was drawn by Dr. John Cronin (Labour) to the steps which are being taken by South Africa and other countries of the Commonwealth to create their own money markets, instead of using the facilities provided by the London market. The Chancellor of the Exchequer, Mr. Peter Thorneycroft, said that he was aware of this tendency and welcomed it, since it should, in due course, increase the efficiency of the financial and monetary techniques of the countries concerned. It might be that in some places the new arrangements would fulfil a function previously discharged in London. In reply to an observation by Mr. Cyril Osborne (Conservative), who said the London money market was falling in importance because Britain did not have the money to lend, Mr. Thorneycroft pointed out that this country was not alone in that respect.

THE HUMAN ELEMENT

Industrial Change and Ourselves

Nearly a year ago at Oxford a conference was convened on the initiative of H.R.H. the Duke of Edinburgh to discuss the impact of industrialism upon human beings. Many leaders of industry took part, drawn from management and labour, but also there were well over 200 much more ordinary people who came to Oxford from all parts of the British Commonwealth and Empire. A full account of the history, the organisation and the proceedings of the conference has now been published by the Oxford University Press in two volumes entitled *His Royal Highness the Duke of Edinburgh's Study on the Human Problems of Industrial Communities within the Commonwealth and Empire* (42*s*.). In this way it is hoped that the value of the contributions and interchange of ideas which took place during a crowded three weeks of July, 1956, would not become mere memories for only those who were there.

The result is a most stimulating report, which captures much of the friendly atmosphere in which the conference was held. It contains the ideas of people, famous and ordinary, who daily come to grip with the human problems in industry. The organisers have achieved what the Duke of Edinburgh considered essential—they have kept " their feet firmly planted on the ground of practical problems and cases." The ideas of individuals, arising from the experience of their work, have through exchange and discussion in a favourable atmosphere, cross-fertilised and produced a most worthwhile contribution to the practice of management. The Duke of Edinburgh and Sir Philip Morris were not alone in their feeling that they had learnt " a very great deal indeed." The conference's scientist chairman, Sir Harold Hartley, the chairman of the Central Electricity Authority, senior managers from many large companies and authorities, the leaders of trade unions—all or most of these men in industry admitted to having learnt a lot. The report goes a long way towards imparting at least some of this knowledge to the general reader.

Purpose and Achievements

The success of the conference was probably due to the very basic and down-to-earth manner in which those who took part made their contributions. It was not allowed to enter what the Duke of Edinburgh calls " the rarefied atmosphere of theory." Commenting on the purpose of such a conference and the desirability of a follow-up, he said " to the practical man engaged in industry it is probably his best chance of discussing his problems in the company of those genuinely seeking a solution. It is also in all probability the most practical way to demonstrate that there is a community of interest between all people in any way directly involved in industry."

In his summing up, Sir Philip Morris, vice-chancellor of the University of Bristol and the holder of several important positions in the world of education (and also vice-chairman of the Board of Governors of the B.B.C.), discussed the idea which led to the conference, " that the present state of human affairs was such that the human problems of communities needed close and intensive study." His historical treatment of the feeling that we live " in an age of turmoil and change " was humorous in its deep wisdom. Every generation since Adam and Eve must have felt that its particular period was a period of turmoil and change. He dismisses the idea that so far as change caused by industrialisation was concerned—change in the daily lives of human beings, in their outlook, their attitudes to one another and to life itself—this country had reached a state of stability. Industrialisation " has something of a wave motion, wave succeeding wave, so that what seemed to be familiar yesterday has taken on a different aspect to-day."

This continuous motion—rather like the reverse of the waves a stone makes when it is thrown in a pond—is a severe challenge to the human beings that make up a society which, by its nature, is far slower to change and has a rhythm of its own quite different from what Sir Philip calls the " waves of this great movement of industrialisation which for the time being is having its way with humanity."

A Humane Movement

The conference achieved more than a mere definition of the problems society faces in promoting industrial growth. It did more than this. Mr. R. K. A. Gardiner, then Permanent Secretary, Ministry of Housing, Gold Coast, presented a paper entitled " The New Industrial Communities in West Africa," and provided what Sir Philip Morris described as a summation of the conference " which should stand in any proper summing up." Mr. Gardiner referred to it as being aimed to establish and further a great humane movement, based upon the dignity of man. He described it as being historic and as no isolated occurrence in British history. At a time when industrial and commercial strife would, he said, help to ensure that industrial enterprises become an integral part of healthy and happy communities, and discharge their responsibilities for helping to foster them.

Basically, the problems that face us centre on these two words: health and happiness. They are not necessarily promoted by scientific and industrial progress. Before our eyes to-day is the disruption created in the industrially backward countries of Africa and the Middle East by the intensive exploitation of their natural resources. Traditional occupations are being supplanted by more lucrative ones, and material gains are disrupting the balance of communal life. What is gained in material well-being can be lost in racial and political conflicts that arise in the destruction of social patterns and the uprooting of communities from the land. What we gain from the development of nuclear power can be lost in the ill-health that could be the inheritance handed over to future generations. The higher productivity and therefore the rise in living standards made possible by the adoption of automatic techniques could be lost in a human wastage, of tradition, skills and social stability. Already we have seen how the adoption of mass production methods have brought the motor car and the refrigerator within the reach of millions. We have seen also the reverse of the medal—the introduction of boredom in work through the break-up of operations into regular repetitive, monotonous patterns of movements and functions. We have seen how the growth of factory life can destroy the harmonious relationship of home and work.

This country and other highly developed industrial states now live with the human problems created by technical changes of the first half of this century. Technical change then outstripped the ability of man and society to keep in step. The second half of the century is bringing about an even greater difference in speed and, one suspects, in direction as well. Such realisations are deeply disturbing, but to see the problems is a step towards their solution. In his summing up, Sir Philip Morris draws attention to those ways—suggested by various speakers—in which men can so shape the direction of scientific development that world society can benefit in the broadest sense. He expresses his conviction that " it is the business of all of us to the maximum of our capacity to understand scientific notions and concepts on an ever advancing scientific front."

One of the characteristics of the conference was that the people taking part were for the most part practical men engaged in industry. But under the leadership of the Duke of Edinburgh these practical men and women were concerned with ways and means to make industrial communities better and happier. The most tangible practical gains arose from statements of experience by people facing the same problems but from various standpoints and in varied surroundings. The Duke of Edinburgh, in his presidential address, emphasised that " every problem of industry or industrialisation looks different, depending on where you see it from." Many irritations and misunderstandings arise from the differences in perspective and standpoint. The people selected to attend the conference were chosen to be representative of all positions in industry—boardroom, shop floor, research, production, trade unions, personnel departments—and of industry in varying stages of development. The interchange of ideas that followed was productive of understanding, from which arise tolerance and the will to co-operate on human problems.

Total Content

Volume 1 contains 17 addresses in addition to the presidential address. All are by men in daily contact with their subject. Sir John Maud, Permanent Secretary, Ministry of Power, talked on " The Impact of Industrialisation ", which few in Britain would be in a better position to observe. Lord Citrine, chairman of the Central Electricity Authority, spoke on " The Varying Pattern of Industry," which he must constantly review and analyse as part of his duties. " The Human Problems of Industry " was the title of five addresses. Mr. A. B. Waring, chairman of Joseph Lucas, who have played a leading part in the promotion of scientific methods of management in Britain, reviewed the pattern of the development of management. Employers and trade unionists gave their views in papers entitled " Why Does Man Work," and " What Does this Mean in Practice." Two most interesting talks were given by Dame Florence Hancock, the chief woman officer of the T. & G.W.U., and Sir Harry Pilkington in " Every-day Relations of Industry and the Community Round It." The Church's point of view was stated by the Archbishop of Canterbury, and Sir Harold Hartley spoke on " The Two Partnerships—Man with Man and Man with Nature."

From overseas, speakers told of growth and social problems in West Africa, Australia, South Africa, India and Canada. Mr. W. J. Bennett's talk—given in his capacity as director and president, Atomic Energy of Canada Limited—was a stimulating and informative account of his country's reaction to industrialisation—perhaps more rapid than anywhere else in the world. All this constituted as comprehensive a view of what the world is doing as has yet been published. From the report, which includes the full accounts of the discussions of 20 study groups which were the working units of the conference, and 25 background papers specially contributed by writers from all parts of the Commonwealth and Empire (given in volume 2), it is possible to form an overall impression of the industrial progress of mankind and quite impossible to under-estimate or overlook the problems that this very progress is bringing about. This injection of realism in the broadest context is valuable indeed. As one speaker stated, and several others implied, the conference was a historical event in a great humane movement. It was symptomatic of man's uneasiness at the unchartered advance of scientific discovery. It is also a timely reminder that humans do not live by bread alone and that those other ingredients necessary to life are not easy to secure and are too easily forgotten.